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The adoption of best management practices in the Louisiana crawfish industry

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THE ADOPTION OF BEST MANAGEMENT PRACTICES IN THE LOUISIANA CRAWFISH INDUSTRY

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To my parents Late Chhabilal Nyaupane and Man Kumari Nyaupane, for their invaluable wishes and support throughout my life………

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ABSTRACT

Agricultural production can have result in environmental deterioration in cases where proper management practices have not been implemented. Louisiana, one of the tropical states, has a significant agricultural base with more than 1,600 farmers raising crawfish. Large volumes of waste water containing environmental pollutants result significant environmental problem in the state. Voluntary adoption of a number of best management practices (BMPs) that are considered to be environmentally and economically beneficial is encouraged in Louisiana.

The major objectives of this study are to investigate farmer adoption of 18 selected Natural Resources Conservation Service (NRCS) cost share eligible BMPs and the reasons for farmers' adoption or non-adoption decisions. The study further analyzes the complementarity or substitutability of different BMPs. A mail survey to 770 Louisiana crawfish producers was conducted in Fall, 2008, based on Dillman's Total Design Method. The adjusted response rate was 15%. Probit, multinomial logit, and t-tests were conducted to analyze the results.

The results of this study showed farmers' land tenancy, education, age, income diversification, and risk-bearing characteristics significantly affecting their probability of adoption. The prerequisite assumption of independence of irrelevant alternatives (IIA) of the multinomial logit model was successful for only two BMPs: Irrigation Land Leveling, and Irrigation Water Conveyance via Pipe; and the results in these two BMPs showed farm size, rotation with other crops, education, farmers' risk averse and early adoption behavior significantly affecting adoption or non-adoption decisions. Some BMPs were also found to have complementary relationships with other BMPs.

CHAPTER 1

INTRODUCTION

United States agriculture constitutes the production of a wide range of crops and animal products due to the availability of a diverse climatic range. Louisiana, one of the sub-tropical states, has a significant agricultural base with aquaculture as one of the major areas in which farmers are concentrated. Louisiana is the largest crawfish producer in United States, with almost 1,600 farms, on more than 184,000 acres of land (LSU AgCenter, 2008). Although production in the wild habitat, mainly in the Atchafalaya River basin, varies in different years, total crawfish production during the 2004-2005 season was recorded as more than 82 million pounds including both farm-raised and wild catch, 74 million and 8 million pounds, respectively (LSU AgCenter, 2007). In 2004-05, total farm-gate and dockside value of crawfish production in Louisiana was around $45 million (LSU AgCenter, 2007). In 2008, production increased to more than 113 million pounds with a gross farm value of about $122 million. A judicious comparison can be made using Table 1.1. There was entry of nearly 400 new crawfish producers during the period with an occupation of more than 60,000 acres of additional land in Louisiana.

Crawfish has been consumed in United States for centuries, but commercial cultivation in Louisiana started in late 19th century (LSU AgCenter, 2007). The study of the history of crawfish production was supported by the Louisiana legislature in 1950; and with the expansion of crawfish production by the 1960s, people in the region were attracted to the economic prospects of crawfish farming (LSU AgCenter, 2007).

Figure 1.1 shows the distribution of crawfish producers in Louisiana parishes. The parishes shown in dark patches, Acadia, Vermilion, and St. Mary, have 131-350 crawfish producers each, the highest in Louisiana. The parishes with semi-dark patches, Avoyelles, Jefferson Davis, Evangeline, Lafourche, St. Landry, and St. Martin, have up to 130 producers each. Parishes with up to 40 producers each include Caddo, Natchitoches, Rapides, Allen, Calcasieu, Concordia, Pointe Coupee, Iberville, Ascension, St. James, Assumption, Terrebonne, Lafayette, and Iberia.

Table 1.1: Crawfish Production in Louisiana 2004-05 and 2008

Categories	**2004/2005**	**2008**
Total Producers	1,200	1,585
Units of Production (Acres)	120,000	184,101
Total Production (lbs.)	82,000,000	113,486,186
Farm-gate and Dockside Value ($)	45,000,000	
Gross Farm Value ($)		122,201,295

Note: Total gross farm value was measured using price of crawfish per pound = $1.08 (Farm) and $0.57 (Wild).

Source: Louisiana Crawfish Production Manual, Louisiana Summary, 2008; LSU AgCenter.

Figure 1.2 demonstrates the total amount of crawfish produced in Louisiana by parishes. Consistent with the previous figure, Acadia was the highest crawfish producing parish in Louisiana, followed by Vermilion, Jefferson Davis, Evangeline, St. Landry, and St. Martin parishes. Figure 1.2 further shows that Avoyelles and Lafourche parishes produced between 2,300,000 and 6,500,000 pounds of crawfish in 2008, followed by the parishes in light patches.

Gross farm value of crawfish production in Louisiana by parish is presented in Figure 1.3. The two Louisiana parishes with the highest gross farm values were Acadia and St. Martin, while those with secondary levels of gross farm value were Vermillion, Jefferson Davis, Evangeline, and St. Landry. Avoyelles and Lafourche had $2.5 million to $7 million gross farm value derived from crawfish.

Given the volume of crawfish farmed in Louisiana, it is important that proper management practices be used to conserve resources. Agriculture is a major source of several nonpoint-source pollutants, including nutrients, sediment, pesticides, and salts. Agricultural nonpoint source pollution reduction policies can be designed to induce producers to change their production practices in ways that improve the environmental and related economic consequences of production (Rahelizatovo, 2004). Ribaudo *et al.* (1999) stated, “The information necessary to design economically efficient pollution control policies is almost always lacking”. Because point sources of pollution were first addressed, agricultural nonpoint sources have been considered as a serious problem that deserves priority (Crutchfield *et al.,* 1995). It has been given priority since 1995 with increased funding for EQIP.

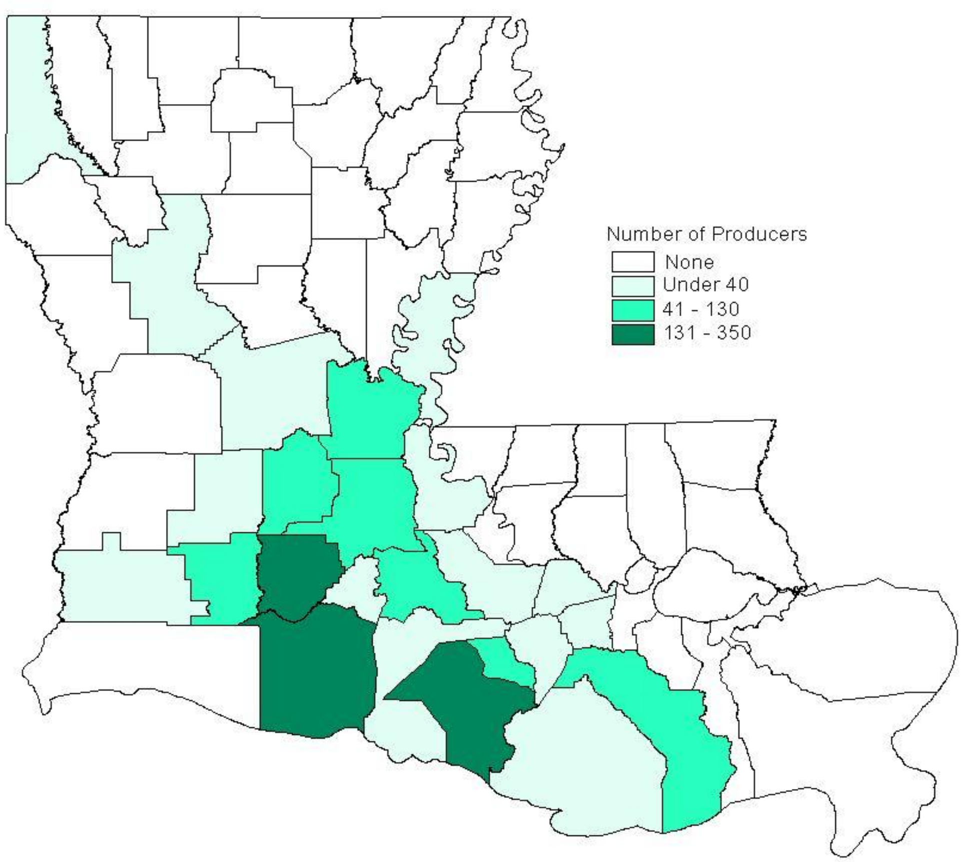

Figure-1.1: Number of Crawfish Producers in Louisiana by Parishes, Source: LSU AgCenter, Louisiana Summary, 2008

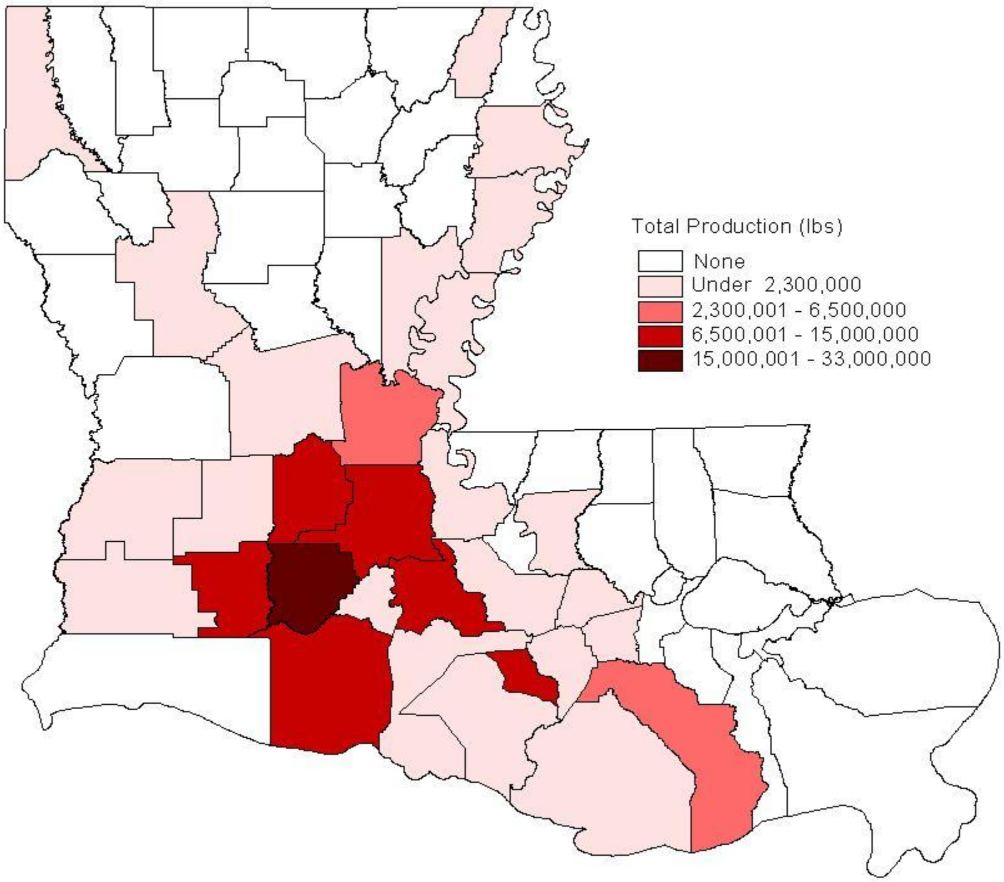

Figure-1.2: Total Crawfish Production in Louisiana by Parishes, Source: LSU AgCenter, Louisiana Summary, 2008

A large amount of waste water disposed from crawfish production systems could have numerous environmental impacts not only related to the other aquatic life but also plants and animals including human beings. Most previous research on crawfish has emphasized various production practices such as pond management, stocking density, time of harvesting and its methods, etc. (LSU AgCenter, 2007), but it has not identified previous research on the environmental issues related to crawfish production methods.

Several other studies in multiple agricultural areas have shown the adoption of Best Management Practices (BMPs) to be helpful in alleviating environmental problems caused by farm practices. In this study, we examine BMP adoption by Louisiana crawfish farmers by conducting probit analyses which allow for investigating the economic and non-economic factors of producers' decisions to adopt a set of BMPs. We further conduct multinomial logit analysis with some possible alternative reasons behind the adoption and paired t-tests for determining whether the adoption of one BMP affects the adoption of others.

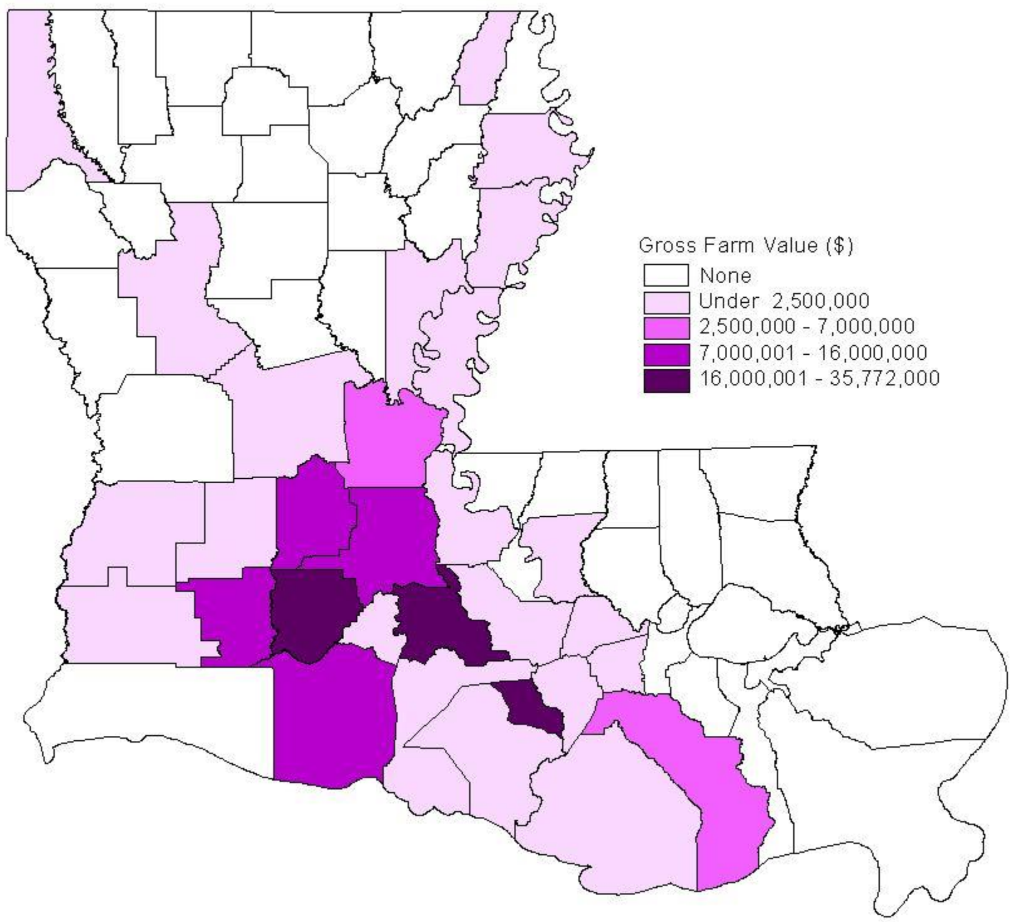

Figure-1.3: Gross Farm Value of Crawfish Production in Louisiana by Parishes, Source: LSU AgCenter, Louisiana Summary, 2008

1.1. PROBLEM STATEMENT

Crawfish production requires large amounts of water in the field for a long duration. Occasional draining and re-flooding are common practices in crawfish systems. Rice-crawfish double crop is one of the more popular practices in Louisiana, which also requires a significant amount of water in the field. The use of tail-water in different farming systems is also observed among producers, which transfers the residuals and leftovers from one field to another.

"Contaminated waters have harmful effects on drinking water supplies, fisheries, recreation, and wildlife" (Rahelizatovo, 2002). The waste water associated with crawfish production must be handled and managed in an environmentally suitable and sustainable manner. Improper waste management may disseminate pollutants to surface and ground waters.

"The Coastal Zone Act Reauthorization Amendment of 1990 (CZARA) states that the state participating in the Coastal Zone Management Act must submit a Coastal Nonpoint Pollution Control Program (CNPCP) to the Secretary of Commerce and the U.S. Environmental Protection Agency for approval" (Henning and Cardona, 2000). The Clean Water Act requires all states in the US to develop rules and enforcement procedures to control nonpoint source pollution. The rules and enforcement procedures will depend upon the specific problems and environment of the state, as established in Section 319. Nonpoint source pollution must be addressed according to Section 319 by assessing problems and causes within the State and by adopting and implementing the management programs (Henning and Cardona, 2000). It is a voluntary task to implement the Coastal Nonpoint Pollution Control Program (CNPCP) in Louisiana (Henning and Cardona, 2000).

To address problems associated with environmental and water quality, voluntary adoption of a number BMPs is established in Louisiana. The Louisiana Department of Environmental Quality (LDEQ) states that, "once education of producers has occurred, and technical assistance and cost share assistance have been offered, if a farmer/producer still does not implement management measures, then the subsequent discharges would be intentional and subject to enforcement action or permitting" (Henning and Cardona, 2000).

Although several programs such as EQIP are implemented in the state to encourage farmers to adopt BMPs for managing environmental pollution, the adoption rate of particular BMPs in this industry is still unknown. Those encouraging adoption have to be able to recognize the types of farmers either willing or hesitating to adopt a new technology, factors driving farmers' decision making, and possible alternative solutions so that educational programs can be targeted.

1.2. JUSTIFICATION

Agriculture is one of the major sources of water pollution, especially in rural communities. Sediment, nutrients, pathogens, pesticides, and salts are some of the common pollutants that agricultural practices discharge to the environment. Agricultural nonpoint pollution can be minimized by adopting certain management practices that are environmentally sustainable. A number of programs are available under the U.S. Department of Agriculture (USDA) as well as at the state level to provide cost share, technical assistance, and economic incentives to the management of nonpoint source pollution (USDA-NRCS, 2009). Many people use their own resources to adopt technologies and practices to limit water quality impacts caused by their agricultural activities.

Significant study has been conducted to understand the extent of adoption of BMPs and their possible contribution to environmental quality. Results show adoption of certain BMPs to be positively associated to the net farm income (NFI), while others potentially related to environmental quality protection show at least a neutral impact on farm income (Valentin *et al.*, 2004). Systems of BMPs are considered to be the effective method for controlling agricultural nonpoint source pollution as they have greater impacts on all three stages, the source, the transport, and the water body, rather than the single BMP.

This study examines the extent of adoption of BMPs in the Louisiana crawfish industry. Minimizing the loss of nutrients and soil as well as controlling microbial contamination and other by-products from the field are the concerns of Louisiana crawfish producers while maintaining or improving agricultural productivity. Eighteen BMPs, supported by Natural Resource Conservation Service (NRCS), are selected for this study, which focuses on the extent of BMP adoption.

1.3. OBJECTIVES

Major objectives of the study are:

1. To assess the extent of current adoption of BMPs in the Louisiana crawfish industry;
2. To determine the effects of demographic, farm characteristics, and diversification factors on crawfish producer BMP adoption decisions;
3. To determine reasons for adoption and non-adoption of BMPs in the Louisiana crawfish industry; and,
4. To determine the relationship of the adoption decision of one BMP with that of another.

1.4. BACKGROUND

1.4.1. Environmental Pollution and the Water Quality Problem

A report by NASA (2002) states that, "Liquid water is a necessity for every form of life known with the possible exception of some plants or fungi that may get by on water vapor." Of the total water on the earth, 97% water is in the ocean and the remaining 3% is fresh water in polar icecaps, permanent snow, lakes, rivers and aquifers (Gleick, 1996). The importance of water can never be underestimated as living beings cannot sustain their lives without water.

Pathogens, sediments, nutrients, and pesticides are common pollutants from agricultural sources. These pollutants are generally carried to water bodies through leaching, run-off, run-in and rainfall, which can be further transmitted to other areas easily. Improper management of contaminated water can lead to various health hazards to living beings, including humans.

Water pollution can be divided into two major categories. A **point source** is defined in Section 502(14) of the Clean Water Act as, “any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture” (EPA, 2008). Another pollution category is a **nonpoint source,** which is defined as any other source of water pollution that is not technically a point source in section 502(14) of the Clean Water Act (EPA, 2008).

The EPA has considered agriculture to be one of the major pollution sources. Significant studies since 1980s have emphasized different aspects of nonpoint pollution sources and their effective management strategies. Agricultural runoff, urban runoff, silviculture, marinas and recreational boating, and canalization and channel modification are considered as five major nonpoint pollution sources (Rahelizatovo, 2002).

1.4.2. Programs Available to Control Water Pollution

Being the major government organization to address environmental issues, the EPA initiated programs early in the mid-twentieth century. The Federal Food, Drug, and Cosmetic Act (1938) and the Federal Water Pollution Control Act (1948) have guided several pollution control programs since their establishment (Rahelizatovo, 2002).

The USDA has worked toward reduction of erosion and increased water quality control at the state, local government and producer levels since the 1930s. Farmers are provided with technical support and encouragement from the Conservation Technical Assistance Program

(CTA) in managing their agricultural nonpoint source pollution at the local level (Rahelizatovo, 2002).

The main objective of the U.S. Clean Water Act (CWA) (1972) was to maintain the nation's water quality level to the optimum chemical, physical, and biological standard (Landry, 2007). Initially, the CWA was focused on point sources of pollution through the National Pollutant Discharge Elimination System (NPDES) program, but the emphasis on nonpoint source pollution was provided once it was amended in 1987. Basic standards of wastewater were set by the EPA in this act, which made it unlawful to discharge pollutants into navigable water without acquiring a special permit (Landry, 2007).

The Coastal Zone Management Act (CZMA), passed in 1972, states that, "land uses in the coastal zone and the use of adjacent lands which drain into the coastal zone, may significantly affect the quality of coastal waters and habitats, and efforts to control coastal water pollution from land use activities must be improved" (EPA, 2009). The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA-1980) provides a Federal "Superfund" to control hazardous-waste sites as well as emergency releases of pollutants and contaminants into the environment (EPA, 2009).

The Marine Protection, Research and Sanctuaries Act, (MPRSA-1972) prohibits dumping pollutants into the ocean unless a special permit is provided (EPA, 2009). The EPA controls hazardous waste under the Resource Conservation and Recovery Act (RCRA-1976), while the amendments of this Act (1986) enabled the EPA to control environmental problems caused by underground wastes. The minimum standard of all tap drinking water is maintained by the EPA under the Safe Water Drinking Act, 1974 (EPA, 2009).

Summary of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA-1996) has provided federal regulation of pesticide distribution, sale, and use in such a way that every pesticide distributed and sold in the United States has to be registered by the EPA and should not generally cause significant health hazards on the environment (EPA, 2009).

Since its establishment in 1935, the USDA Natural Resource Conservation Service has assisted private land owners and managers in conserving soil, water, and other natural resources by providing technical as well as financial assistance (USDA-NRCS, 2009). The Environmental Quality Incentives Program (EQIP), established in 1996 under the Federal Agriculture Improvement and Reform Act (the 1996 Farm Bill), is jointly administered by the USDA-NRCS and the Farm Service Agency (FSA). It offers financial and technical assistance to eligible participants in installing or implementing BMPs on suitable agricultural land. The Farm Security and Rural Investment Act of 2002 (the 2002 Farm Bill) confirmed authorization of EQIP (USDA-NRCS, 2009). The new farm bill (2008) has been targeted to simplify existing programs and develop new strategies to address priority conservation priorities (USDA-NRCS, 2010).

1.4.2.1. Louisiana and Conservation Programs

A number of conservation practices are eligible to receive financial support from NRCS based on a 2008 payment schedule. The incentive payments may cover 75 percent of the total cost, but limited resource producers and beginning farmers may be eligible for cost-shares of 90 percent. It is generally $300,000 over a six year period but can be increased to $450,000 with secretary of agriculture's approval for special projects of environmental significance (USDA-NRCS, 2009).

The Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), a public law passed by Congress in November 1990, directs its main emphasis to coastal wetland protection. In February 2008, there were “145 active CWPPRA projects, 74 had been constructed, 17 were under construction, and 20 had been de-authorized. NRCS is the federal sponsor for 55

CWPPRA projects benefiting 36,596 acres of Louisiana's valuable coastal wetlands" (USDA-NRCS, 2009).

The Conservation Security Program (CSP) is a voluntary approach that covers conservation practices beyond those implemented on-farm, unlike other programs. It provides financial and technical support to those who wish to adopt natural resource conservation practices on their land and, more importantly, farmers with good performance in soil and water conservation are offered special rewards. Incentives are also offered to innovative farmers who wish to implement conservation practices at more than just a minimum standard. Moreover, providing stewardship ensures that private agricultural land remain viable to work as an enterprise. In 2008, the Tickfaw watershed, spreading throughout most part of the St. Helena and Livingston Parishes, as well as some part of the Tangipahoa Parish, was selected for Conservation Security Program focus in Louisiana (USDA-NRCS, 2009).

Other conservation programs include the Grazing Lands Conservation Initiative (GLCI-1991), and Grassland Reserve Program (GRP). The GLCI is a voluntary program that encourages private land owners to use conservation practices on their grazing land by providing technical assistance. The GRP helps landowners to protect their grassland, pastureland, rangeland and grazing land while maintaining both shrubs or forbs and plant biodiversity. Further, the GLCI, a coalition of private grazing land owners and managers, targets the priority issues related to the improvement of private grazing lands, whereas the GRP emphasizes operations on the areas with greatest threat of conversion (USDA-NRCS, 2009).

The Small Watershed Program (Public Law 566), established under the Watershed Protection and Flood Prevention Act (Public Law 83-566), is another successful program in Louisiana since 1954, with the completion of 34 projects (3.8 million acres) including 11 active projects (1.8 million acres) developing 2,900 miles of channel with pipe drops (erosion control structures), 150 weirs/grade stabilization structures, and 36 dams and other similar supporting programs in controlling erosion or managing water quality (USDA-NRCS, 2009). Small watershed projects provide support to the problems too big to be managed by individual participants but are possible to be supported by federal and state projects for water resource development (USDA-NRCS, 2009).

Federal and state agencies, private industry, environmental groups, and local district groups implemented the Louisiana State Wildlife Habitat Incentives Program Plan (WHIP), developed in the 1996 Farm Bill, to improve habitat and associated wildlife that had been impacted by agricultural and forestry activities (USDA-NRCS, 2008). Through WHIP, USDA-NRCS prioritizes and provides cost-shares to areas that are not addressed by other programs, especially to those wanting to develop wildlife habitat on private land. It supports up to a 75% cost-share with a contract of five to ten years to establish and improve fish and wild-life habitat. In Louisiana, the major priority is being provided to those habitat types that have been impacted by agricultural and forestry activities (USDA-NRCS, 2008).

The Wetland Reserve Program (WRP) is a competitive program to fund the environmentally most beneficial practices that protect, enhance, and restore wetlands while maximizing wildlife benefits. To be eligible, the land should be restorable, and be suitable for wildlife so that restoration and protection could be administered through a voluntary and environmentally sustainable manner (USDA-NRCS, 2008).

1.4.3. Best Management Practices

Braune and Wood (1999) defined the BMP as “a multi-disciplinary approach in applying appropriate technology to preserve the natural environment, enhance living standards, and improve the quality of life.” They discussed environmental problems created by urbanization, and possible solutions by the use of BMPs. A better understanding of the development impacts and the cost-effective solutions of water quality problems were the major benefits of BMPs (Braune and Wood, 1999).

According to Boucher *et al.* (1995), BMPs are "those on-farm activities designed to reduce nutrient losses in drainage waters to an environmentally acceptable level while simultaneously maintaining an economically viable farming operation for the grower." They also suggested that practices negatively related to economic profitability are not considered to be BMPs. If the practices are eligible to receive cost share or incentive payments to raise the profitability of adoption to an acceptable level, then they can be considered as BMPs. They discussed the implementation strategies of BMPs via three strategies: voluntary, incentive and enforcement methods. Voluntary strategies include all methods that make farmers aware of BMPs and increase their knowledge of implications, whereas incentive payments are external funds made available to the farmers to attract them to adopt. Some rules and regulations could also be made to enforce farmers to adopt BMPs for environmental benefits (Boucher *et al.*, 1995).

Paudel *et al*. (2008) referred to BMPs as "voluntary practices that producers adopt or structures they build to manage resources and mitigate environmental pollution from agriculture". Producers' lack of information about the profitability and the environmental benefits of adopting BMPs may be one of the problems affecting the control of agricultural nonpoint sources of pollution (Ipe *et al.*, 2001; Feather and Amacher, 1994). In addition, there are insufficient funds available to accept all BMPs applied for funding.

1.4.3.1. Best Management Practices for Crawfish Production in Louisiana

A number of BMPs are considered to be particularly applicable to crawfish production. Listed are the BMPs and the description as provided by the National Handbook of Conservation Practices (NHCP), USDA-NRCS.

Conservation Cover (NRCS Code 327) is the practice of establishing and maintaining permanent vegetative cover which aims to reduce soil erosion, improve soil, water, and air quality, or promote wildlife habitat. All lands requiring permanent vegetation are suitable for conservation cover. Plants conducive for local wildlife and soil condition, and producing organic matters are commonly selected for this practice (USDA-NRCS, NHCP, 2007).

Critical Area Planting (NRCS Code 342) is the practice of establishing permanent vegetation on the areas with high erosion risks, and on sites that are unsuitable for growing vegetation with normal cultivation strategies. Areas highly disturbed by human activities or natural disasters are suitable for this practice (USDA-NRCS, NHCP, 2007).

A **Field Border (NRCS Code 386)** is a strip of permanent vegetation established at the edge or around the perimeter of the field to reduce soil erosion, to increase carbon storage, to preserve the wildlife population, or to manage water quality (USDA-NRCS, NHCP, 2007).

A **Grade Stabilization Structure (NRCS Code 410)** is a grade controlling structure in natural or artificial channels. It reduces pollution and increases environmental quality by minimizing erosion and preventing the formation of gullies (USDA-NRCS, NHCP, 1985).

A **Filter Strip (NRCS Code 393)** is a strip or area of small vegetation aimed at removing suspended contaminants from overflow or irrigation tail-water. This is established in environmentally-sensitive areas where frequency of water overflow with sediment and other pollutants are common (USDA-NRCS, NHCP, 2008).

A **Grassed Waterway (NRCS Code 412)** is a natural or constructed channel with vegetation shaped in a particular dimension to help in reducing erosion and improving water quality. This practice can also be accompanied with other conservation strategies to control erosion where frequent runoffs are common (USDA-NRCS, NHCP, 2000).

Irrigation Water Management (NRCS Code 449) is "the process of determining and controlling the volume, frequency and application rate of irrigation water in a planned, efficient manner" (NRCS-USDA, NHCP, 2005). It benefits the farm by managing soil moisture, minimizing erosion, decreasing non-point source pollution, managing the soil, air, and plant micro-climate and improving air quality (USDA-NRCS, NHCP, 2005).

Irrigation Land Leveling (NRCS Code 464) is a practice of reshaping or leveling the land surface for the uniform and efficient application of irrigation water. A detailed engineering study of the land is required before its reshaping so that long run productivity as well as profitability would be increased (USDA-NRCS, NHCP, 2001).

An **Irrigation Storage Reservoir (NRCS Code 436)** is a structure made by constructing a dam, embankment or pit, to store water until it is used for crop irrigation. This practice is useful only when the site is suitable for constructing an artificial structure, and available flow water is insufficient to meet year-round supply (USDA-NRCS, NHCP, 2002).

An **Irrigation Regulating Reservoir (NRCS Code 552)** is a small storage reservoir, designed to store water for a short period of time. It controls tail-water as well as offsite water and ultimately improves the irrigation water management. This practice is suitable on sites where an adequate amount of water can be made available from storage and where water must be stored between the irrigation rotations (USDA-NRCS, NHCP, 2002).

Irrigation System, Tail-water Recovery (NRCS Code 447) is a planned irrigation system where structures for collection, storage, and transportation of irrigation tail-water are properly constructed. It helps in reusing tail-water and therefore improves the offsite water quality. This practice requires a properly designed and installed irrigation system (USDA-NRCS, NHCP, 2007).

Irrigation Water Conveyance via Pipe (NRCS Code 430) is a pipeline installed in an irrigation system with the major objectives of preventing erosion, maintaining water quality, or minimizing damage to the land. Further, it not only minimizes seepage and evaporation loss, but also reduces the water flow time, thus increasing an overall efficiency of irrigation water management (USDA-NRCS, NHCP, 1988).

Nutrient Management (NRCS Code 590) is the practice of "managing the amount, source, placement, form and timing of the application of plant nutrients and soil amendments" (USDA-NRCS, NHCP, 2006). The major purposes of nutrient management are to reduce agricultural non-point source pollution of ground water resources, to minimize nitrogen emissions into the air in order to maintain environmental quality, and to maintain an equilibrium of soil physical, chemical, and biological integrity (USDA-NRCS, NHCP, 2006).

A **Pumping Plant (NRCS Code 533)** is a facility installed to transfer water benefitting a farm by providing both a dependable water source and a disposal facility for water management. It is commonly used wherever water must be pumped in order to maintain a critical water level (USDA-NRCS, NHCP, 2002).

Range Planting (NRCS Code 550) is the establishment of perennial vegetation in order to relieve an erosion problem and improve water quality. It can also improve forage quality and increases carbon sequestration. On sites where vegetation by grazing management is unsatisfactory, grasses, forbs, legumes, shrubs or trees suitable to the local climatic conditions are considered and the acceptable level of plant population is maintained (USDA-NRCS, NHCP, 2003).

A **Riparian Forest Buffer (NRCS Code 391)** is an area adjacent to water sources where trees and/or shrubs are conserved for maintaining water temperature, restoring riparian plant communities, reducing pesticide contamination into the water body, and minimizing sediment, organic material, and nutrients in surface runoff. Riparian forest buffers are commonly practiced on areas close to streams, lakes, ponds, and wetlands (USDA-NRCS, NHCP, 2006).

Streambank and Shoreline Protection (NRCS Code 580) is a conservation practice aimed to maintain and protect banks of streams or constructed channels, and shorelines of lakes, reservoirs, or estuaries. It reduces the flow capacity of streams and thus minimizes the loss of river banks. This practice is applicable on sites of high erosion susceptibility (USDA-NRCS, NHCP, 2005).

Tree Shrub Establishment (NRCS Code 612) is the practice of establishing locally adapted woody plant species on suitable sites in order to improve natural diversity, control erosion, store carbon in biomass, and conserve energy. Fast growing varieties with extensive root systems and high nutrient uptake capacity are preferred (USDA-NRCS, NHCP, 2006).

1.5. THESIS OUTLINE

Chapter 2 covers the review of literature dealing with technology adoption, adoption of best management practices, and other similar environmental studies. Chapter 3 describes the data collection, a conceptual framework for data analysis, and discusses methods for empirical estimation of data collected through a mail survey of Louisiana crawfish producers in Fall, 2008. Chapter 4 includes the empirical results of the study. A detailed description of the achieved results is presented in this chapter. Chapter 5 provides a summary of the research results. It outlines and concludes the present study.

CHAPTER 2

LITERATURE REVIEW

In this chapter, several previous studies on technology adoption, water quality, and the adoption of BMPs are discussed. The first section deals with a number of research findings about technology adoption and water quality while the second section presents a comprehensive background on BMP adoption issues.

2.1. TECHNOLOGY ADOPTION AND WATER QUALITY

One of the most extensive studies on technology adoption was conducted by Feder, Just and Zilberman (1985), a survey of previous studies dealing with adoption of agricultural innovations in developing countries which examines factors commonly affecting adoption decisions such as level of information, risk and uncertainty, farm size, farm tenure arrangements, and others. They considered aggregation of adoption, discussing the overall diffusion pattern of a technology, and also raised the issue of adoption intensity and its change over time.

Hornsby *et al.* (1993) discussed managing pesticides for crop production and water quality protection by using practical grower guides. The study emphasized the importance of developing producer awareness about water quality control. The decision aids developed by the US Department of Agriculture Soil Conservation Service and the Florida Cooperative Extension Service were considered to be the main focus of selection criteria of the pesticide. Both pesticide parameters (relative leaching potential index, relative run-off potential index, lifetime health advisory level or equivalent, aquatic toxicity, parameter convention) and soil parameters (leaching, run-off) should be considered to the environmental and ecological benefit while selecting a pesticide. It was suggested that policy makers assist the producers to be well-informed, but not force them to adopt.

Saha *et al.* (1994) developed a model of an individual producer's decision to adopt a divisible technology in the presence of risk. They examined the adoption of rBST (recombinant bovine somatotropin), a high yield-enhancing growth hormone, which was expected to increase milk production by 10-20 % per cow. They focused on the analytical and empirical implications of incomplete information in the adoption process. Though most previous research had been focused on dichotomous adoption decisions (adoption or non-adoption), this study analyzed the degree and intensity of adoption along with the "whether or not to adopt" choice. The adoption process passes through three consecutive states: information collection, whether or not to adopt, and how much to adopt. The results showed that the adoption decision was directly affected by the producer's perception of rBST-induced yield and adoption costs. Risk attitude and perceptions about the degree of risk associated with the new technology had no influence on the adoption decision.

Zepeda (1994) examined simultaneity of technology adoption and productivity by using data from 153 randomly selected California Grade-A milk producers. She considered that single-equation estimates of an *ex post* model of technology adoption were subject to simultaneity bias as the technology adoption decision and productivity were jointly determined. She developed a generalized probit model with continuous and discrete endogenous variables to estimate the parameters with desirable asymptotic properties. The effect of productivity on the technology adoption decision was studied and the results were compared to biased single-equation estimates. The results indicated the joint dependence of endogenous variables, which suggested the need to correct for simultaneous equation bias in technology adoption studies. Single equations may overestimate the significance of the relationship as well as lead to different conclusions concerning the factors affecting technology adoption.

Caffey and Kazmierczak (1994) studied the factors influencing technology adoption in Louisiana aquaculture systems by collecting data from soft-shelled crab producers by personal interviews in 1991. Despite having incomplete information for generating hypotheses, it was hypothesized that the level of technology adoption, size of the firm, information sources, experience, local competition, management, and an off-farm job were the major variables affecting the adoption of the available technologies. The authors used a multinomial logit model to analyze the factors associated with float-car, flow-through and re-circulating technology adoption. Although the lack of a proper relationship between producers and information sources created some problems, the rate of technology adoption could be increased by effective educational programs targeted to the full-time, family operated businesses.

Fernandez-Cornejo *et al.* (1994) studied the factors affecting the adoption of Integrated Pest Management (IPM) practices using data from vegetable growers in Florida, Michigan, and Texas. It was mentioned that health and environmental hazards of pesticides could be managed by IPM techniques which combine cultural, biological, and chemical measures to reduce the pest population below a threshold level. Rogers (1983) emphasized that the rate of adoption is characterized by five major qualities: perception, compatibility, complexity, feasibility, and visibility. He further divided the adopter's qualities into five different types: innovators, early adopters, early majority, late majority, and laggard (p. 263). These qualities were also considered in the IPM study where risk perceptions, farm structure, crops grown, and other important factors were hypothesized to affect the adoption decision. Multinomial logit analysis confirmed that the adopters were greater risk-takers than non-adopters. Farm size, family labor, and availability of irrigation were positively related with the adoption of IPM. The study further concluded that locational factors and the type of crop grown had significant effects on IPM adoption.

Premkumar and Roberts (1999) investigated factors affecting the use of information technologies and their potential adoption in rural businesses. Rural businesses have both opportunities and obstacles in competitive markets that are full of technological innovations. The impacts of ten independent variables within three broad topics of innovation, organization and environment were analyzed in the model. Innovational characteristics included relative advantage, cost, complexity, and compatibility; organizational characteristics were top management support, IT-expertise, and size of the business; and environmental characteristics were competitive pressure, vertical linkages and external support. E-mail, online data access, internet access and EDI were four communicational technologies used as dependent variables in the study. Data collected by using a structured survey of 78 organizations in five rural communities in a mid-western state in the US were analyzed using multivariate discriminate analysis. The research findings identified that relative advantage, top management support, size, external pressure, and competitive pressure were the major factors influencing the adoption of communication technologies in rural businesses.

El-Osta and Morehart (1999) investigated the role of herd expansion on the probability of technology adoption among several mutually exclusive technologies. The data were based on a survey sample of dairy farms of fifteen states from the Farm Costs and Returns Survey (FCRS) rather than just one state as in some of the previous studies. The authors developed a multinomial logit model. Results showed that higher technology adoption was significantly related to higher dairy production. The likelihood of capital intensive technology adoption was increased by specialization, age, and size of the farm, whereas management intensive technologies were positively influenced by education and size of the farm.

2.2. BEST MANAGEMENT PRACTICES (BMP) ADOPTION

A number of previous studies have examined the adoption of BMPs (e.g., Lichtenberg *et al.*,1990; Baker and Mickelson, 1994; Kochenderfer *et al.,* 1997; Srivastava *et al.,* 2002; Wang *et al.*, 2002; Prokopy *et al.*, 2008; Campbell, 2008; Mukherjee, 2009). In this section, those studies that are most relevant to the current study will be reviewed.

Logan (1993) mentioned that national awareness of environmental contamination due to agricultural practices dates back at least to 1962. Non-point source pollution by phosphorous was regarded to be a significant contributor via untreated domestic waste water. At the same time, several agricultural practices such as the use of fertilizers and pesticides were shown to be major contributors to high nitrate levels in some rivers and water wells, as well as sediment contamination in water bodies in agricultural areas. To supplement existing BMPs designed particularly to control the soil erosion, Logan (1993) emphasized the use of fertility and pest management practices in an integrated approach.

Feather and Amacher (1994) investigated the role of information in the adoption of best management practices for water quality improvement. The data from an adoption survey conducted by USDA to evaluate a demonstration project were used. The first stage of the two-stage model used in the study analyzed how producer perceptions of risk, profitability, and improvements in environmental quality influenced adoption. The second stage evaluated BMP adoption. The results showed that knowledge significantly influences adoption rates.

Traore *et al.* (1998) examined the roles of perception, environmental quality awareness and farm characteristics on adoption of conservation practices by using survey data of potato farmers in Quebec, Canada. A two-stage model consisted of the perception and adoption stages which analyzed the farmer's awareness of environmental degradation and analysis of the rate of adoption of conservation practices to overcome the problem. Maximum likelihood estimates of the first stage of the two-stage probit-model were used as explanatory variables in the second stage. Farmer's educational level, perception of an environmental problem, the expected crop loss to pests and weeds, the perceived health effects of farm chemical application, and information availability were found to be the major factors affecting the adoption of BMPs.

Henning and Cardona (2000) used multivariate probit analysis to analyze the factors affecting the adoption of BMPs in the Louisiana sugarcane industry. Three management measures identified by federal EPA guidelines were considered in the analysis: soil erosion, nutrient management, and pesticide management. Two types of variables, institutional and socio-economic, were used in their study. They found that education and cost-sharing programs were effective means of increasing adoption rates. More than 90 percent adoption of at least one BMP was found where risk of yield loss was not a factor. Meeting with extension personnel greatly influenced adoption.

D'Arcy and Frost (2001) studied the potential role of BMPs to reduce water quality problems related to diffuse pollution. Some possible management measures to control the quality of both urban and rural run-off were considered, but because of no single point of discharge in diffuse pollution sources, the only way to overcome the problem was via the adoption of BMPs. They emphasized effective monitoring strategies on land-use decisions, to overcome the problem of diffuse pollution.

Valentin *et al.* (2004) explored the empirical relationship between adoption of BMPs and farm profitability by using survey data from the membership of the Kansas Farm Management Association. They developed a mathematical form of a profit equation by using nutrient, herbicide and conservation index groups and considering three types of independent variables: crop acreage, the percentage of labor devoted to livestock production, and BMP adoption indices. Results showed that the adoption of nutrient BMPs had a positive effect on profit for wheat and corn, while that of herbicide BMPs had a small negative impact on net farm income. In addition, soil conservation BMPs did not have a statistically significant impact.

Rahelizatovo and Gillespie (2004) examined the adoption of BMPs by Louisiana dairy producers by using count data analysis. The intensity and determinants of technology adoption in a particular time was estimated by using poisson and negative binomial regressions. Results showed that producers' awareness, information about BMPs, farm size, education and risk version characteristics were significantly affecting adoption decisions.

Gillespie *et al.* (2007) conducted a survey of cattle producers to investigate the rate of adoption and non-adoption of BMPs. Sixteen BMPs suggested by the Louisiana State University Agricultural Center to manage the water quality problem were examined. The impact of exogenous variables was analyzed by using a multinomial logit model. Influences of farm type, information sources, input quality, and situational and attitudinal variables to the non-adoption of BMPs were studied. Results showed unfamiliarity and non-applicability to be the most common reasons for non-adoption. Other reasons included high cost, still considering adoption, and a preference to not adopt.

Paudel *et al.* (2008) studied the impact of socioeconomic factors and significant steps associated to the adoption of 18 BMPs suitable for the Louisiana dairy industry. In addition to identifying the positive impacts of cost-share and incentive payments by using logit analysis, they considered how BMP adoption differed at specific steps in the adoption process and found that interaction with NRCS personnel significantly improved adoption rates. Consistent with Feather and Amacher (1994), they suggested bundling and efficient targeting of BMPs to be possible alternatives to improve water quality. Evaluation of willingness-to-pay results showed possible marginal increases in adoption would require increased technical and financial assistance.

Prokopy *et al.* (2008) reviewed 25 years of adoption literature and investigated general trends of the determinants of the adoption of agricultural BMPs. They divided the determinants into four major categories: capacity, awareness, attitudes, and farm categories. The vote count method was used to sum up the total of positive, negative and neutral relationships of the determinants of adoption decisions. Most of the 55 articles dealt with soil, nutrients, and pest management practices as dependent variables while farmer age and education were the most common independent variables. Some of the variables often found to be positively related to the adoption decisions were education, capital, income, farm size, access to information, and positive environmental attitude.

CHAPTER 3

DATA AND METHODOLOGY

3.1. THEORETICAL FRAMEWORK

3.1.1. Background

Economics is a social science similar to political science, sociology and psychology. Economists have provided a number of definitions, but the common theme is always "concerned with overcoming the effects of scarcity by improving the efficiency with which scarce resources are allocated among their many competing uses, so as to best satisfy human wants" (Cramer and Jensen, 1982). The comparison of benefits (results) being achieved from an action with the sacrifices (costs) is considered as one of the major driving factors in the economic decision making process. Cramer and Jensen (1982) further defined agricultural economics as "an applied social science dealing with how mankind chooses to use technical knowledge and scarce productive resources such as land, labor, capital, and management to produce food and fiber and to distribute it for consumption to various members of society over time".

In agricultural economics, a person's decision is generally based on either of these three major economic principles: increase in production, cost minimization (profit maximization) or utility maximization. Utility maximization is associated with efficient use of scarce resources or budget in monetary terms or an increase in production. This form of decision making constitutes a 'rational theory' which is widely used in the social sciences. Economists argue that this theory provides a rigorous and common framework to understand human behavior and correlates aggregate events to micro-level decision making (Friedman and Hechter, 1988). Although some critics have suggested that it has some unrealistic assumptions, individual decisions and actions are guided by rational preferences (likes and dislikes) and constrained by limited resources, opportunity cost, institutional norms, and quality of information (Rahelizatovo, 2002).

Henderson and Poole (1991, p. 44) define opportunity cost of a good or action as "the best alternative that is given up in order to produce the good or follow the course of action". The level of information is considered an important factor in a producer's decision making process not only because it is advantageous in distinguishing alternative choices but also in reducing uncertainty and risk associated with the system.

3.1.2. Individual Preferences

The theory of consumer behavior describes how consumers allocate their incomes among different goods and services to maximize their well-being. Three distinct factors are responsible for consumer behavior. These are: 1) consumer preferences, 2) budget constraints and 3) consumer choices (Pindyck and Rubinfeld, 2007, p. 64).

The theory of consumer preference has three basic assumptions. First, preferences are assumed to be complete, meaning that consumers can compare and rank available goods and services. Thus, for any two goods A and B, a consumer will prefer A to B, will prefer B to A, or will be indifferent between the two. Second, preferences are transitive, meaning that if a consumer prefers good basket A to basket B, and basket B to basket C, then the consumer also prefers A to C. Third, consumers always prefer more goods to less (Pindyck and Rubinfeld, 2007, p. 66).

Consumer preference is associated with utility. Utility is a numerical score representing the satisfaction achieved from consumption of particular goods and services. It is the pleasure by which consumers can simplify the ranking of market baskets. Consumers choose an option with higher utility; however, if the associated cost is also increased, a person is less likely to choose that option (Pindyck and Rubinfeld, 2007, p. 75). In other words, a rational and feasible choice is based on both available resources (income) and individual preference. Satisfaction is maximized when the marginal benefit associated with the consumption of one additional unit of good equals to the marginal cost. The utility below this equilibrium is less than that a person could achieve with the available resources whereas the utility above the equilibrium is unattainable in prevailing conditions.

3.1.3. Theoretical Model

It is assumed that Louisiana crawfish producers adopt BMPs to maximize their utility. The following simple 'utility maximization' model has been proposed in this study.

(1) *Adoption of BMPs = f (demographic variables; diversification variables; attitudinal variables).*

Consistent with an adoption model suggested by Kim *et al.* (2008), we hypothesize that farmers adopt technology if the utility is greater from adoption than that of non-adoption.

(2) $U(Adoption) \geq U(Non\text{-}Adoption)$.

where $U(.) = Utility$.

3.2. ECONOMETRIC MODELS

3.2.1. Discrete Choice Modeling

Conventional regression methods are inappropriate in qualitative response (QR) models in which the dependent variable is an indicator of a discrete choice, such as a "yes or no" decision (Greene, 2008). In most cases, the values of the dependent variables are merely a coding for some qualitative outcome affected by a number of factors. Greene (2008) shows that the outcome set to a number of factors can be interpreted in following ways.

(3) $Prob\ (Y = 1 \mid x) = F\ (x, \beta)$

(4) $Prob\ (Y = 0 \mid x) = 1 - F\ (x, \beta)$

where x is a vector of explanatory variables and β is the respective impact of a change in x on the probability.

We can denote $F(x, \beta) = x^{'}\beta$. Then, the regression model would be as follows:

(5) $Y = E[y \mid x] + (y - E[y \mid x]) = x^{'}\beta + \varepsilon$

Since $x^{'}\beta + \varepsilon$ must be equal to 0 or 1, ε equals either - $x^{'}\beta$ or $(1 - x^{'}\beta)$, with probabilities $1 - F$ and F, respectively, leading to generating this equation easily (Green, 2008).

(6) $Var[\varepsilon \mid x] = x^{'}\beta\,(1 - x^{'}\beta)$

Since $x^{'}\beta$ cannot be constrained to the 0 – 1 interval and produces negative variances with incorrect probabilities, the linear model is not commonly used in such analyses leading to a probit model.

3.2.2. Utility Function

A similar study related to best management practice adoption rates among Southwest Louisiana rice producers was Landry (2007). It was assumed that the farmers adopt a technology only if the perceived utility is more than that from non-adoption. The model represented unobserved utility (U_{ij}) as follows (Landry, 2007):

(7) $U_{i1} = \overline{Ui1} + e_{i1} = z'_{i1}\delta + w'_{i}y_{1} + e_{i1}$

(8) $U_{i0} = \overline{Ui0} + e_{i0} = z'_{i0}\delta + w'_{i}y_{0} + e_{i0}$

where the utility achieved from choosing an alternative by an individual i is denoted as U_{i1}, whereas that for not choosing an alternative is U_{i0}. The average utilities and the vectors of both alternatives are denoted as $\overline{Ui1}$, $\overline{Ui0}$ and z'_{i1}, z'_{i0}. Socioeconomic characteristics of an individual are w'_{i} and e_{i1} and e_{i0} are the error terms (Judge *et al*., 1988).

Maddala (1986) suggested the following method to evaluate the unobserved utility:

(9) $Y_{i} = U_{i1} - U_{i0}$

$= (z_{i1} - z_{i0})'\, \delta + (y_1 - y_0)'\, w'_i + (e_{i1} - e_{i0})$

$= x_{i'}\beta + e_i^*$

where $x_{i'}$ represents the vector of regressors which are assumed to influence the outcome Y_i, β are unknown parameters typically estimated using maximum likelihood, and e_i^* is the random error in the model.

3.2.3. Probit Models

Judge *et al*. (1988) suggested two probability distributions for estimating a discrete choice model: the probit (normal distribution) function and the logistic distribution function. The choice between these two depends upon the individual researcher to some extent and the nature of study. The cumulative distribution function for the standard normal distribution is as follows (Heij *et al.*, 2004):

(10) $$F(t) = \int_{-\infty}^{\infty} (2\pi)^{-1/2} \, exp\left\{-\frac{x^2}{2}\right\} dx$$

And the cumulative distribution function for the logistic distribution is:

(11) $$F(t) = \frac{1}{1+exp^{-t}}$$

Although Greene (2008) mentioned that both of these distributions are symmetrically bell shaped with a zero mean, a number of similar previous studies such as Landry (2007) and Zhong (2003) used probit models in their analyses. Likewise, we prefer using the probit model in this study.

Using the probit model, which assumes a normal distribution, the probability of adoption is modeled as shown in Greene (2008) (1):

(12) $$\Pr(Y{=}1) = \int_{-\infty}^{x'\beta} \Phi(t)dt = \Phi(x'\beta)$$

where $\phi(.)$ denotes the standard normal distribution, (Y=1) suggests the BMP was adopted, and x

represents independent variables expected to influence adoption. Marginal effects for continuous variables are estimated as:

$$(13) \qquad \frac{\partial E[Y|x]}{\partial x} = \Phi(x'\beta)\beta$$

Marginal effects for dummy variables, *d*, are estimated as:

$$(14) \qquad \Pr[Y = 1|\bar{x}_*, d = 1] - \Pr[Y = 1|\bar{x}_*, d = 0]$$

where $\bar{x}_*$ refers to all variables other than *d* held at their mean values.

3.2.4. Multinomial Logit

Multinomial logit models are applied if the nominal dependent variables have multiple categories that cannot be ordered practically. One category of the dependent variable is considered as the base category and the relationship of independent variables to all other categories are compared with the base. As mentioned by Nerlove and Press (1973), the model is:

$$(15) \qquad \text{Prob } (Y_i = j) = \frac{e^{\beta_j' xi}}{\sum_k^j e^{\beta_j' xi}}$$

where, y_i is the observed outcome for the *i*th individual with a vector of x_i. The estimated equations provide a set of probabilities for the $J+1$ choices with characteristics x_i (Greene 2000). To remove indeterminacy in the model, the normalization procedure should be considered by taking $\beta_0 = 0$. Now, the probabilities would be as follows, as suggested by Greene (2000).

$$(16) \qquad \text{Prob } (Y_i = j|x_i) = \frac{e^{\beta_j' xi}}{1 + \sum_{k=1}^j e^{\beta_j' xi}} \text{ for } j = 0, 2, \ldots, J, \beta_0 = 0.$$

where *Pr(.)* represents probability, *j* is one of *J* choices, and β are parameters to be estimated. Marginal effects for continuous variables are estimated at their mean values, while those for dummy variables are estimated as:

$$(17) \qquad \Pr[Y_j = 1 \mid \bar{x}_*, d = 1] - \Pr[Y_j = 1 \mid \bar{x}_*, d = 0]$$

where *d* is represents the dummy variable (Greene, 2000).

3.2.5. T-test

The relationship of the adoption of a BMP among a group of adopters and non-adopters of another BMP is tested by using a paired sample t-test analysis. In the first phase, adoption and non-adoption rates of a BMP is calculated. The second phase estimates the adoption rates of another BMP within the groups of adopters and non-adopters calculated in the first phase. T-test compares the equality of two means obtained in the second phase.

As mentioned by Zar (1984), the two-tailed hypothesis can be interpreted as follows:

$H_0: (\mu_1 - \mu_2) = 0$

$H_1: (\mu_1 - \mu_2) \neq 0$

$\alpha = 0.10$

where μ_1 and μ_2 denote the adoption means estimated in the second phase analysis. Level of significance for this study was chosen as 10%.

If the mean difference of adopters of one BMP between the adopters and non-adopters of other is $\bar{x}$, then the test statistics for the null hypothesis is represented by following equation (Zar, 1984).

$$t = \frac{\bar{x}}{Sd/\sqrt{n}} \quad (18)$$

where Sd is the standard deviation of the test and n is the total number of observation. If the t-test statistic value obtained from the analysis is smaller than the t-test critical value at the level of significance of 10%, the difference between means would not be considered significant, and vice versa.

3.3. SPECIAL TESTS

3.3.1. Multicollinearity

Independent variables in an econometric model can be approximately linearly related. This is a data problem that complicates estimation and the interpretation of model results. Perfectly correlated variables have an infinite variance. Exact relationship among the independent variables is a serious failure to meet the assumptions of a model (Greene 2000). Highly correlated variables may cause several statistical problems such as wide swings in the parameter estimates, coefficients with high standard errors, and wrong signs. Variance inflation factors as well as the condition index were estimated by using SAS software. A value of variance inflation factor of 5 or greater and that of the condition index in excess of 20 or higher is used as an indication of linear dependence (Greene, 2000).

3.3.2. Heteroskedasticity

Violation of an assumption of equal variances across random variables is known as heteroskedasticity, which is one of the first tests to conduct in any statistical analysis. The variance σ^2 is a measure of dispersion of the residuals around the mean of zero. The errors are assumed to be distributed independently across their random variables with a constant variance σ^2. When this assumption does not hold, the heteroskedasticity problem is present. Although the properties of unbiasedness and consistency are not violated by ignoring heteroskedasticity in an OLS regression, the results are considered as inefficient because of the larger covariance matrix. In a probit model, heteroskedastic errors with a wrong covariance matrix may lead to a biased and inconsistent maximum likelihood estimator (Rahelizatovo, 2002). Robust standard errors were estimated in STATA to minimize the errors from this problem (Greene, 2000).

3.3.3. Testing for the Assumption of Independence of Irrelevant Alternatives (IIA) in the Multinomial Logit Model

The "multinomial logit model must satisfy a probabilistic version of the assumption of the independence of irrelevant alternatives, implying that the ratio of the probabilities for two alternatives does not depend on what other alternatives are available" (Stata Manual, 2003 p. 128). As proposed by Hausman and McFadden (1984), the Hausman Specification Test has been the standard test for IIA, but it has a number of limitations such as: (1) statistics may be undefined if the asymptotic properties of the test are not met; (2) the classic Hausman test only applies for the equality of two estimators; and (3) it requires a fully efficient estimator, but in complex survey data, an efficient estimator is sometimes impractical to achieve (Stata Manual, 2003 p. 128).

To overcome these limitations, SUEST (Seemingly Unrelated Estimation) was suggested. According to the Stata Manual (2003, p. 128), "It combines the estimation results (parameter estimates and associated (co)variance matrices) stored under name list into a single parameter vector and simultaneous (co)variance matrix of the sandwich/robust type". HAUSMAN and SUEST differ in using an estimator of the variance (Stata Manual, 2003). The HAUSMAN test estimates *V(b-B)* by *V(b)-V(B)* while SUEST estimates *V(b-B) by V(b)-cov(b,B)-cov(B,b)+V(B)* (Stata Manual, 2003**,** p. 132). The assumption of IIA is rejected if the probability of chi-square result falls below 0.5, in the 5% level of significance and vice versa.

3.4. SURVEY DESIGN AND DATA COLLECTION

The extent of BMP adoption in Louisiana crawfish production is assessed using crawfish producer responses obtained from a mail survey conducted during Fall, 2008, to 770 Louisiana crawfish producers who were on the mailing list of crawfish newsletters sent by the LSU Agricultural Center. Dillman's Total Design Method was used for implementing the survey (Dillman, 1978).

The questionnaire was eight pages long including a cover page that included the title, a picture of crawfish being harvested, and no questions. Producers were asked a variety of questions including general production practice and BMP adoption, tenancy arrangements, participation in the Environmental Quality Incentives Program (EQIP), use of various record-keeping systems, and demographic and general farm information. The first mailing, in

September 2008, included the questionnaire. Each letter was personally addressed and signed and first-class mail was used. This was followed by a postcard reminder approximately 1 ½ weeks later to all who received the survey. A second copy of the survey was then sent to non-responders via first-class mail approximately 1 ½ weeks after the postcard reminder. Finally, a second postcard reminder was sent to all non-responders approximately 1 ½ weeks after the second survey. Thus, four contacts were made to producers. Samples of the cover letter for each of the mailings and the postcard reminder are presented in Appendix.

Of the 770 who were sent surveys, 79 were returned as non-deliverable, 185 were sent back with the respondent stating that they had not produced crawfish during the 2007-2008 production season, and 75 were returned as completed surveys. The adjusted population was measured by deducting the producers who did not produce crawfish during the 2007-2008 season and the non-deliverable surveys from the total population of 770, thus making the final population of 506 the truly surveyed, resulting in an adjusted response rate of 15%, as shown in Figures 3.1 and 3.2.

3.5. DATA

3.5.1. Crawfish Production System

The structure of the crawfish industry is influenced by the land leasing system and the system of production. Therefore, a number of questions included those dealing with land tenancy and farmers' selected production systems. The first question asked whether the respondent produced crawfish during 2007-2008. If "Yes", they were requested to complete the survey. Otherwise, they were requested to send the survey back by marking the "No" answer option. The number of acres of land including both owned and leased was the second question. We asked further about the leasing system in the following section to those farmers who did not own their

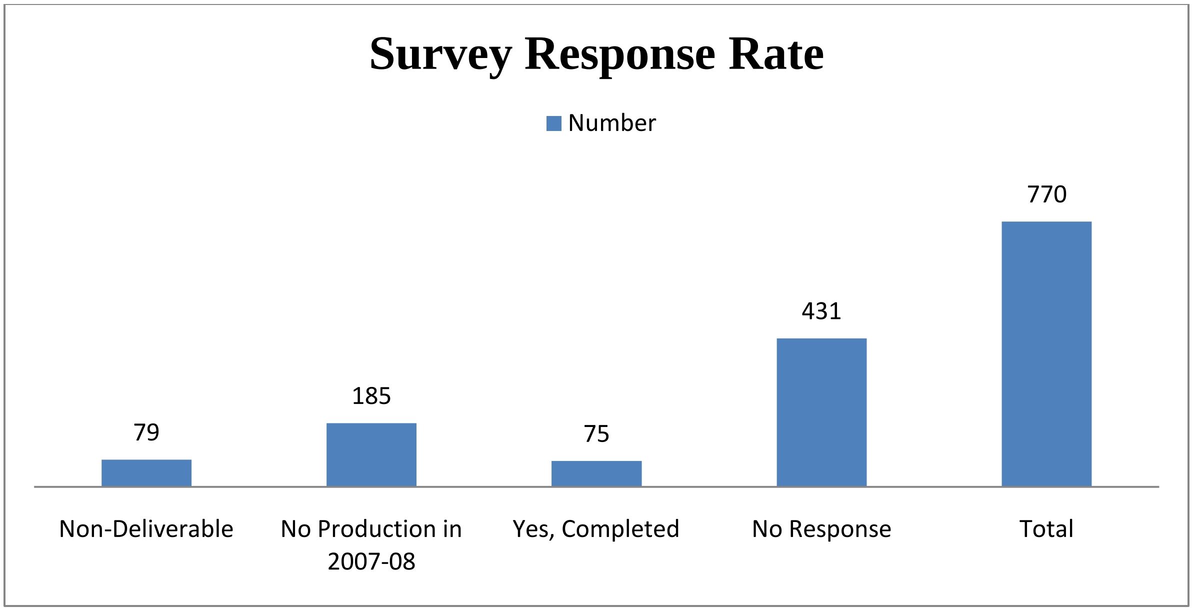

Figure – 3.1: Unadjusted Survey Response Rate

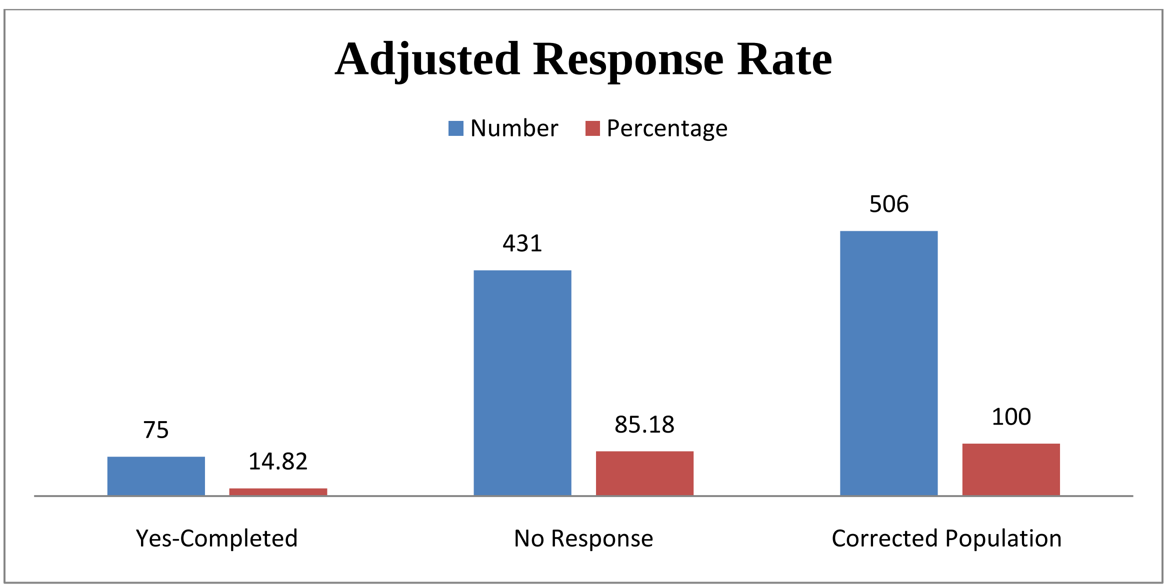

Figure – 3.2: Adjusted Response Rate

entire farm. The types of production systems and land area under each system were asked as follows: "On your farm, including both owned and rented land, how many acres do you operate in each of the following production systems?" Categories were: Rice-Crawfish Double Crop, Rice-Crawfish-Fallow Rotation, Rice-Crawfish-Soybeans Rotation, Single-crop Crawfish with

Rice Forage, Single-crop Crawfish with Other Planted Forage and Single-crop Crawfish with Non-Planted Forage Crop. System descriptions were included.

Questions about the adoption of a number of technologies such as the use of types and sizes of pumps, method of harvesting, type of boats used and test of oxygen were also included in the survey, as shown in the Appendix.

3.5.2. Best Management Practices

Adoption of 18 separate BMPs listed in Table 3.1 was asked with 10 potential choices, only one of which was to be chosen. Answer choices included two columns, one with five “Yes” alternatives and the other with five “No” choices. Farmers’ economics, environmental awareness, as well as their perception of the suitability of their farm for the BMP were covered in answer choices. More specifically, choices included “Yes, I adopted it because it leads to increased profit,” “Yes, I adopted it because it is good for the environment,” “Yes, I adopted it because I have been encouraged / required to do so,” “Yes, I established it because it’s good for long-run land productivity,” “Yes, this practice was established by the landowner or another tenant,” “No, I am not familiar with this practice,” “No, this doesn’t apply to my farm,” “No, this would reduce my profit,” “No, I am still considering doing this,” and “No, I prefer not to do this.” Each BMP was provided with a brief description to assist the respondents in recognizing distinct differences among closely related practices, as shown in the survey in the Appendix.

A question about the distance of the nearest stream or river from the farm was included in the survey. One of the important sources of information to Louisiana crawfish producers is meeting with Natural Resource Conservation Service (NRCS) personnel and Louisiana Cooperative Extension Service personnel. The frequency of visits and attended seminars from each were collected in the range of none, 1, 2, 3, and ≥ 4.

3.5.3. Producer Characteristics and Demographics

Producers' individual characteristics often play a major role in their decision making processes. In this section, we asked questions about their age, level of education, years of farming and similar other demographic variables. Education was categorized into five different levels, less than high school, high school diploma/GED, some college / technical school, bachelor's degree, and advanced degree (M.S., Ph.D., J.D., M.D., etc). Diversification variables associated with the farm were solicited by asking about household and their farming income coming from crawfish in 2007. Producer's involvement in off-farm work was solicited via the question, "Do you hold an off-farm job?"

Farmers were asked the question, "Relative to other investors, how would you characterize yourself?" They were requested to characterize themselves into one of three sub-groups, "I tend to take on substantial levels of risk in my investment decisions", "I tend to avoid risk when possible in my investment decisions", or "I neither seek nor avoid risk in my investment decisions". Producers with the first choice were considered risk prone, the second were risk averse, and the third risk neutral. This question was originally used by Fausti and Gillespie (2006) in a survey of risk preferences of beef cattle producers.

3.6. VARIABLES USED IN THE PROBIT AND MULTINOMIAL LOGIT ANALYSIS

3.6.1. Dependent Variables

Among a number of possible BMPs applicable to crawfish production in Louisiana, a list of 18 NRCS cost-share eligible BMPs was collected from the Louisiana NRCS state office. Individual BMPs shown in Table 3.1 constitute a separate equation with all explanatory variables in the probit model and further analysis.

3.6.2. Independent Variables

Table 3.2 shows a number of factors expected to influence the adoption decision considered in the analysis. Those factors were classified into four sub-groups. From all 13 variables selected, six were farm characteristics, three were operator's characteristics, and two were in each of the diversification and attitudinal categories.

Table 3.1: Dependent Variables (BMPs)

Best Management Practices			
1.	Conservation Cover	10.	Irrigation Regulatory Reservoir
2.	Critical Area Planting	11.	Irrigation System TWR
3.	Field Border	12.	Irrigation Water Conveyance Pipe
4.	Grade Stabilization Structure	13.	Nutrient Management
5.	Filter Strips	14.	Pumping Plant
6.	Grassed Waterways	15.	Range Planting
7.	Irrigation Water Management	16.	Riparian Forest Buffer
8.	Irrigation Land Leveling	17.	Streambank and Shoreline Protection
9.	Irrigation Storage Reservoir	18.	Tree Shrub Establishment

3.6.2.1. Farm Characteristics

ACRES is the number of acres on the farm. Larger-sized farms have generally been associated with an increased likelihood to adopt technology (El-Osta and Morehart, 1999; Gillespie *et al.*, 2004). This was used as a continuous variable in the study. Higher fixed cost of production has generally been negatively associated with technology adoption (Feder *et al.*, 1985). *CASH* and *SHARE* indicate whether the producer rents crawfish land using a cash lease or a share lease, respectively. Previous research has shown the land tenure system to be important in affecting the adoption of conservation practices (Soule *et al.*, 2000). Cardona (1999) suggested that farmers are less likely to adopt BMPs on rented land. In this study, we hypothesize the ownership of land to be positively associated with adoption. Two variables are used as dummies (1 or 0) in this study.

ROTATION is a dummy variable that is '1' if the crawfish land is rotated with rice, soybeans or fallow, and '0' if not. *DOUBLECROP* is the condition of whether the crawfish land is double cropped with rice or not. Farmers' land use in both the rice-crawfish-fallow rotation and the rice-crawfish-soybean rotation were collected and combined to construct the variable *ROTATION*, whereas land used under rice-crawfish double-crop system was considered as *DOUBLECROP*. Both dummy variables were expected to show some mixed effects in BMP adoption.

The proximity of a stream to the farm is expected to increase adoption of most BMPs. Although a *STREAM* flowing through the farm would be advantageous to maintain a good irrigation and water management system, land next to streams would be particularly vulnerable to polluting the waterway. Farmers were asked, "how far from your crawfish farm is the nearest stream or river?" with a first answer choice, "a stream/river runs through my farm" which was used as a dummy variable in the study. Consistent with Rahelizatovo and Gillespie (2004), *STREAM* was expected to be positively associated with the implementation of BMPs, especially those specific to bodies of water such as stream-bank and shoreline protection.

3.6.2.2. Operator's Characteristics

Two variables, *AGE* and *EDUCATION*, were included in this category, both of which have been shown to affect farmers' adoption decisions in a number of previous studies (Zepeda, 1994; Cardona, 1999; El-Osta and Morehart, 1999; Soule *et al*., 2000). Most research shows younger farmers to be the most innovative adopters. Paudel *et al.* (2008) mentioned that a relatively new entrant would be more likely to adopt a new technology. Farmer age was classified into five equal-interval categories, less than 30 years, 31-45, 46-60, 61-75, and more than 76, making age as a continuous variable. These are essentially equal-interval categories since no farmer was expected to be <15 or >90 years of age.

Education is another factor expected to affect adoption decisions (Feder *et al.*, 1985; Cardona, 1999; El-Osta and Morehart, 1999; Soule *et al*., 2000; Traore, Landry, and Amara, 1998). Education opens up a broad view of information in the industry and therefore farmers can choose among different opportunities in farming. A more educated producer is expected to enter the crawfish industry to minimize his opportunity cost of farming by being as profitable as possible with the adoption of suitable technologies. Farmers with at least a college bachelor's degree and those without a high school diploma were analyzed using two dummy variables, *COLLEGE* and *NO HSCHOOL*.

3.6.2.3. Diversification Variables

Two variables, *FARMINCOME* and *HHINCOME*, were included in the study to understand the possible effect of diversification associated with the adoption decision. *FARMINCOME* was the percent of farm income from the crawfish operation, while the percent of household income from the farming operation was included as *HHINCOME*. Feder *et al.* (1985) discussed the effect of credit constraints in the adoption of a technology, and suggested that off-farm income can increase the probability of adoption because of the greater availability of working capital. Generally, income is expected to be positively associated with the adoption decision because farmers with more income are less likely to be financially constrained in implementing any of those BMPs. Diversification may detract farmers from adoption due to managerial counteracts. It may also be positive if the BMP is adopted for the other enterprise, such as rice.

3.6.2.4. Attitudinal Variables

Risk and uncertainty were previously discussed as important factors affecting technology adoption (Fernandez-Cornejo *et al*., 1994). Two variables *RISK AVERSE* and *TECHADOPTEARLY* were selected to measure the effect of farmers' characteristics on BMP adoption. The way farmers consider themselves as either risk averter, risk neutral, or risk taker; and adopting or not adopting technology earlier than other similar farmers were two important dummy variables used in this study. Consistent with the way Fausti and Gillespie (2006) considered *RISK* in their study, a question was asked, “Relative to the other investors, how would you characterize yourself? (i) I tend to take on substantial levels of risk in my investment decisions; (ii) I tend to avoid risk when possible in my investment decisions; and (iii) I neither seek nor avoid risk in my investment decisions.” The *RISKAVERSE* farmers were assumed to be those who selected (ii).

Producer risk bearing characteristics are not always sufficient to indicate when a farmer adopts a new technology on his farm. The way producers consider themselves to be early adopters, mid-adopters, and late adopters of a new technology, is considered as a potentially important factor affecting the adoption rate at a particular time. The variable, *TECHADOPTEARLY* was selected and assumed to be positively associated with adoption decision of BMPs.

Table 3.2: Explanatory Variables Included in the Models

Variables		**Definition**
Farm Characteristics		
1	*ACRES*	Cts: Number of acres on the farm
2	*CASH*	Dummy: Producer rents crawfish land using a cash lease = 1
3	*SHARE*	Dummy: Producer rents crawfish land using a share lease = 1
4	*ROTATION*	Cts: Portion of crawfish land rotated with rice and/or soybeans
5	*DOUBLECROP*	Cts: Portion of crawfish land double cropped with rice
6	*STREAM*	Dummy: Farmer response, “A stream/river runs through my farm” = 1

Table 3.2, Continued

Variables		Definition
Operator's Characteristics		
1	*AGE*	Cts: Farmer's age
3	*COLLEGE*	Dummy: Producer holds a college bachelor's degree or more = 1
4	*NO HIGHSCHOOL*	Dummy: Producer without a high school degree = 1
Diversification Variables		
1	*FARMINCOME*	Cts: Percent of farm income from the crawfish operation; 1: 1-19%; 2: 20-39%; 3: 40-59%; 4: 60-79%; 5: 80-100%
2	*HHINCOME*	Cts: Percent of household income from the farming operation; 1: 1-19%; 2: 20-39%; 3: 40-59%; 4: 60-79%; 5: 80-100%
Attitudinal Variables		
1	*RISKAVERSE*	Dummy: Farmer response, "I tend to avoid risk when possible in my investment decisions" = 1
2	*TECHADOPTEARLY*	Dummy: Farmer response, "I tend to adopt new technology earlier than most of my neighbors" = 1

CHAPTER 4

RESULTS AND DISCUSSION

This chapter is divided into three parts. The first section deals with the descriptive analysis of farm characteristics as well as various factors affecting adoption of best management practices. The second section discusses the adoption results from probit analyses and the reasons for adoption or non-adoption using the multinomial logit analysis. The third section provides t-test results of the differences in percent adoption of individual BMPs out of both non-adoption and adoption frequencies of a particular BMP.

4.1. DESCRIPTIVE STATISTICS

4.1.1. Descriptive Statistics of Independent Variables

Table 4.1 shows the general descriptive statistics of the independent variables chosen for the BMP study. The land used in the crawfish production per farmer varies greatly, with an average of more than 650 acres of land. This land could be owned by the farmer himself or be acquired via lease. Use of a cash share is more than twice (33%) as common as use of a share lease (16%).

Percentages of farmers practicing double-cropping (28%) and those producing crawfish in rotation with other crops (31%) are almost the same. The percentage of farmers having at least a college degree is more than four times (30%) that of holding no high school diploma (7%). More than half of the survey population (51%) considered themselves as risk-averse, but only 32% considered themselves as early adopters of technology.

4.1.2. Demographic Characteristics of Survey Population

Table 4.2 presents the general characteristics of the survey population of crawfish producers in Louisiana. Of the total of 75 responses, very few respondents hesitated to provide

Table 4.1: Descriptive Statistics of Independent Variables

Independent variables		Std. Dev.	Mean
Acres	Cts: Number of acres on the farm	843.96	661.68
Cash	Dummy: Producer rents crawfish land using a cash lease = 1	0.47	0.33
Share	Dummy: Producer rents crawfish land using a share lease = 1	0.37	0.16
Doublecrop	Cts: Portion of crawfish land double cropped with rice	0.45	0.28
Rotation	Cts: Portion of crawfish land rotated with rice and/or soybeans	0.46	0.31
Age	Cts: Farmer's age; 1: ≤30; 2: 31-45; 3: 46-60; 4: 61-75; 5: >75	0.67	3.07
College	Dummy: Producer holds a college bachelor's degree or more = 1	0.46	0.30
No h-school	Dummy: Producer without a high school degree = 1	0.25	0.07
Farmincome	Cts: Percent of farm income from the crawfish operation; 1: 1-19%; 2: 20-39%; 3: 40-59%; 4: 60-79%; 5: 80-100%	1.49	2.15
Hhincome	Cts: Percent of household income from the farming operation; 1: 1-19%; 2: 20-39%; 3: 40-59%; 4: 60-79%; 5: 80-100%	1.66	3.03
Riskaverse	Dummy: Farmer response, "I tend to avoid risk when possible in my investment decisions" = 1	0.50	0.51
Early-adopt	Dummy: Farmer response, "I tend to adopt new technology earlier than most of my neighbors" = 1	0.46	0.32
Stream	Dummy: Farmer response, "A stream/river runs through my farm" = 1	0.49	0.42

Table 4.2: Frequencies/Percentages of Independent Variables under Different Answer Categories: Farmers' Demographics

Years of Farming: How many years have you been farming crawfish?		
Categories (years)	**Frequency**	**Percentage**
1-7	8	10.96
8-14	20	27.40
15-21	14	19.18
22-28	16	21.92
29-35	9	12.32
36-42	3	4.11
≥43	3	4.11
Total	73	100.00
Off-Job: Do you hold an off-farm job?		
Yes	31	43.06
No	41	56.94
Total	72	100.00
Education: Please indicate your highest level of education.		
<HS (Less than High School)	5	6.85
HS (High School)	25	34.25
Some College	21	28.77
Bachelor or Advanced	22	30.13
Total	73	100.00
Age: Please indicate your age.		
≤45	11	15.07
46-60	46	63.01
≥61	16	21.92
Total	73	100.00

their demographics; the total numbers of responses are provided in the table. The percentage of farmers producing crawfish for 8-14 years (27.40%) was greater than those of other categories.

There were fewer farmers holding off-farm jobs (43%) than those not being engaged in off-farm employment (57%). Regarding the education level of the sample, the highest percentage of the producers were high-school graduates (34.25%) whereas the producers with some college or a bachelor's degree were roughly equal in proportion.

The age range of the producers was highest at 46-60 years (63.01%). Additionally, more farmers were in ≥61 years' range than in the ≤45 range, showing either the greater inclination of older people to remain in this production system for many years or their greater willingness to complete the survey.

4.1.3. Farm Size and Tenure System

Crawfish farmers' farm size and tenure system are presented in Table 4.3. Although an open survey question was asked about the total acres of land used in this production system, five categories with equal intervals of 100 acres have been presented in the table with their respective frequencies and percentages. Almost one third (28.37%) of the total population uses less than 100 acres of land for crawfish production and a relatively large percentage has more than 500 acres of land showing a wide range of land distribution in the industry. Most of the sample (63%) does not own all of its land used in crawfish production. Of the 47 not owning all of their crawfish producing land, the highest proportion (41.30%) of farmers rent ≥80% of their land from a third party. In terms of the lease system prevalent in the industry, of the producers renting land, more than twice the number of renters pay in cash rather than use a share lease.

4.1.4. Diversification Variables; Land Characteristics; NRCS, LCESP, and EQIP Participation

Table 4.4 provides information about farmers economic output generated by farming

Table 4.3: Farm Size and Tenure System

Farm Size: How many acres of land are included in your entire farm operation including both owned and leased?		
Categories (Acres)	**Frequency**	**Percentage**
<100	21	28.37
100-199	12	16.21
200-299	9	12.16
300-399	2	2.71
400-499	2	2.71
≥500	28	37.84
Total	74	100.00
Own: Do you own all of the land you raise crawfish on?		
Yes	28	37.33
No	47	62.67
Total	75	100.00
% Rent: Approximately what percentage of your total crawfish land do you rent?		
1-20	6	13.04
21-40	4	8.70
41-60	10	21.74
61-80	7	15.22
≥80	19	41.30
Total	46	100.00
Lease System: Is this a cash lease or a share lease?		
Cash Lease	25	56.82
Share Lease	12	27.27
Combination	7	15.91
Total	44	100.00

system and overall crawfish production. Results show that half of the respondents (50%) received relatively low percentages (1-19%) of farming income from crawfish production in 2007. Only 12.5% of producers had more than 80% of their farming income from crawfish production. The percentages of farmers receiving <20% and ≥80% of their household incomes from farming were 26% each.

The frequencies and percentages of farmers having business contact with either Natural Resource Conservation Service (NRCS) or Louisiana Cooperative Extension Service (LCES) personnel are provided in Table 4.5. Almost 40% of producers said that they had no business contacts with NRCS personnel during the 2007 season, whereas nearly one quarter (23.19%) of producers had ≥4 contacts during the year. The percentage of people having business contact with LCES personnel ≥4 times in the past year was more (30.77%) than those having not a single business contact (21.54%). A relatively higher proportion of the producer sample attended meetings once (27.69%) or twice (16.92%) during the year.

Table 4.6 provides a general overview of land erodibility and the presence of a stream in the area, as well as an exploration of EQIP participation among producers. Results show that, in general, crawfish farms are located close to a stream/river, with a distance of less than one mile. More than 41% of producers said that a river/stream flows through their farm. Only 20.83% of the respondents said that the distance of a river/stream from their farm is more than one mile.

Although some of the crawfish producing land was considered erodible (13.70%), most of it was non-erodible (68.49%). Eighteen percent of producers were unaware of the status of their land in terms of erodibility. Table 4.6 further shows that 54% of the producers are participating in some form government cost share program, such as the Environmental Quality Incentives Program (EQIP).

Table 4.4: Diversification Variables

Farmincome: Approximately what percentage of your farming income came from crawfish in 2007?		
Categories (Percentage)	**Frequency**	**Percentage**
1-19	36	50.00
20-39	12	16.67
40-59	8	11.11
60-79	7	9.72
80-100	9	12.50
Total	72	100.00
HH-income: Approximately what percentage of your total household income came from the farming operation in 2007?		
1-19	19	26.39
20-39	12	16.67
40-59	5	6.94
60-79	17	23.61
80-100	19	26.39
Total	72	100.00

Table 4.5: Institutional Variables

NRCS: Over the past year, approximately how many business contacts (visits, attended seminars, etc.) have you had with Natural Resource Conservation Service personnel?		
Categories	**Frequency**	**Percentage**
None	27	39.13
1	11	15.94
2	9	13.04
3	6	8.70
≥4	16	23.19
Total	69	100.00

Table 4.5, Continued

LCESP: Over the past year, approximately how many business contacts (visits, attended seminars, etc.) have you had with Louisiana Cooperative Extension Service personnel?

Categories	Frequency	Percentage
None	14	21.54
1	18	27.69
2	11	16.92
3	2	3.08
≥4	20	30.77
Total	65	100.00

Table 4.6: Stream, Land Erodibility and EQIP Participation

Stream: How far from your crawfish farm is the nearest stream or river?

Categories	Frequency	Percentage
A stream/river runs through the farm	30	41.67
Runs through ≤1 mile	27	37.50
Runs through >1 mile	15	20.83
Total	72	100.00
Land Erodibility: Is any of the land on your farming operation considered highly erodible?		
Yes	10	13.70
No	50	68.49
Don't Know	13	17.81
Total	73	100.00
EQIP Participation: Have you participated in any government cost-sharing programs such as the Environmental Quality Incentives Program (EQIP) while implementing a BMP?		
Yes	38	53.52
No	33	46.48
Total	71	100.00

4.1.5. Attitudinal Variables

Farmers' attitude towards risk and technology adoption is described in Table 4.7. Compared to the risk takers (22.54%) and risk neutral farmers (26.76%), the proportion of crawfish farmers reluctant to take on substantial risk in their decision making processes is relatively high (50.70%). Although most of the farmers were found to be risk averse, the percentages of early (31.94%) and middle (38.89%) adopters of a technology were higher than that of late adopters (29.17%).

4.2. PROBIT RESULTS

Table 4.8 shows percentages of producers adopting each BMP. The most highly adopted BMP was Irrigation Water Management, with a 79% adoption rate. Following that, Irrigation Land Leveling had an adoption rate of 75%. Irrigation Water Conveyance via a Pipeline, Nutrient Management, and Conservation Cover followed with >50% adoption rates each. Practices with lower (<15%) adoption rates were Range Planting, Irrigation Regulating Reservoir, Tree / Shrub Establishment, Irrigation System with Tailwater Recovery, Riparian Forest Buffer, and Irrigation Storage Reservoir, Irrigation Regulating Reservoir, and Streambank and Shoreline Protection. Each BMP would not necessarily be suitable for every farm, depending upon land and farm characteristics, as well as other crops raised on the farm.

Tables 4.9 and 4.10 show the results of the probit runs. Table 4.9 presents details with β coefficients and marginal effects and Table 4.10 summarizes the results as to whether independent variables had positive or negatively significant effects on adoption, for comparison purposes. Goodness of fit varied by BMP, with the pseudo R-square ranging from 0.1327 for Field Border to 0.4043 for Irrigation System with Tailwater Recovery. Variation Inflation Factor and Condition Indices were examined, with no evidence of multicollinearity found. Summary results of multicollinearity analyses are provided in Table 4.11 while the details are provided in

Table 4.7: Attitudinal Variables

Risk: Relative to other investors; how would you characterize yourself?		
Categories	**Frequency**	**Percentage**
Risk Averse: I tend to avoid risk when possible in my investment decisions.	36	50.70
Risk Neutral: I neither seek nor avoid risk in my investment decisions.	19	26.76
Risk Taker: I tend to take on substantial levels of risk in my investment decisions.	16	22.54
Total	71	100.00
Adoption Characteristics: Compared to other farmers in your area, which of the following best describes your willingness to adopt new technologies?		
Early: I tend to adopt new technology earlier than most of my neighbors.	23	31.94
Middle: I tend to adopt new technology along with most of my neighbors.	28	38.89
Late: I tend to wait until others have adopted new technology to see how well the technology works before adopting.	21	29.17
Total	72	100.00

appendix. The number of observations used for the probit models ranged from 63 to 68, depending upon the number of completed responses. The relatively small number of observations likely contributes to relatively low levels of significance in some of the runs.

Table 4.8: Adoption Rates of the Best Management Practices Used in Crawfish Production

Best Management Practice	Percent Adopted	Best Management Practice	Percent Adopted
Irrigation water management	79	Pumping plant	24
Irrigation land leveling	75	Grassed waterway	17
Irrigation water conveyance via pipeline	61	Irrigation system with tailwater recovery	14
Nutrient management	57	Irrigation regulating reservoir	11
Conservation cover	54	Range planting	10
Critical area planting	47	Irrigation storage reservoir	7
Field border	40	Tree/shrub establishment	7
Grade stabilization structure	39	Riparian forest buffer	4
Filter strips	24	Streambank & shoreline protection	3

As expected, the larger the farm, the more likely the adoption of three BMPs, Irrigation Water Management, Irrigation Water Conveyance via a Pipeline, and Pumping Plant. All three of these BMPs deal with irrigation water and its transfer, and are likely to require significant initial capital investment that would be associated with significant economies of size in adoption. Cash lease shows negative association with five BMPs, some of which would be more capital intensive in nature, such as a pumping plant, and others which are less capital-intensive but nevertheless involve investment in the land resource, such as a Field Border. Holding a share lease was negatively related to the adoption of Grassed Waterways. This suggests that rental arrangements generally have negative effects on BMP adoption, a result that is not surprising given the disincentive for farmers to make significant land improvement investments on rented land.

Table 4.9: Coefficients and Marginal Effects of Probit Best Management Practice Adoption Runs

Variables	Conservation cover				Critical area planting				Field border				Grade stbln structure			
	Coefficient		Marg. effect		Coefficient		Marg. effect		Coefficient		Marg. effect		Coefficient		Marg. effect	
Acres	0.00018		0.00007		0.00033		0.00013		-0.00007		-0.00002		-0.00033		-0.00012	
Cash	0.12810		0.05068		0.40076		0.15876		-0.81525	*	-0.27874	**	-0.78598	*	-0.27072	**
Share	0.67994		0.25275		0.17046		0.06788		-0.32452		-0.11460		0.36179		0.13921	
Doublecrop	0.11330		0.04479		0.45009		0.17799		0.48161		0.18445		0.74571		0.28647	
Rotation	-0.81585	*	-0.31589	*	-0.49259		-0.19103		-0.12233		-0.04498		0.58439		0.22282	
Age	0.60820	***	0.24141	***	0.44486	*	0.17673	*	0.30207		0.11220		-0.19653		-0.07320	
College	-0.48910		-0.19318		0.32109		0.12749		-0.27641		-0.10029		0.04670		0.01745	
No h-school	0.71255		0.25643		0.38735		0.15309		0.58235		0.22744		2.16681	**	0.64373	***
Farmincome	-0.23044	*	-0.09147	*	-0.07051		-0.02801		-0.05048		-0.01875		-0.12078		-0.04498	
Hhincome	0.07036		0.02793		0.00969		0.00385		-0.07514		-0.02791		0.28477	**	0.10606	**
Riskaverse	-0.33674		-0.13304		0.09493		0.03770		0.04003		0.01487		-0.07563		-0.02816	
Early-adopt	1.16757	***	0.42383	***	1.02275	***	0.38950	***	-0.38537		-0.13861		1.13274	***	0.42291	***
Stream	-0.59127	*	-0.23224	*	-0.23267		-0.09204		-0.24136		-0.08878		0.87165	**	0.32317	**
Obs	66				68				67				67			
Pseudo R^2	0.2237				0.1667				0.1327				0.2987			

Notes: *** indicates the variable is significant at the 0.01 level; ** indicates the variable is significant at the 0.05 level; *indicates the variable is significant at the 0.10 level.

Table 4.9, Continued

Variables	Filter strips				Grassed waterways				Irrgn. water management				Irrigation land leveling			
	Coefficient		Marg. effect		Coefficient		Marg. effect		Coefficient		Marg. effect		Coefficient		Marg. effect	
Acres	0.00034		0.00009		-0.00003		-0.00001		0.00085	*	0.00020	**	-0.00008		-0.00002	
Cash	-0.42151		-0.09863		-0.91323	*	-0.12389	*	-0.84500	**	-0.22279	*	0.36831		0.09592	
Share	0.38972		0.10993		-1.70199	**	-0.14169	***	-0.19068		-0.04701		0.48001		0.11325	
Doublecrop	0.30258		0.08174		1.61774	***	0.41919	**	0.70720		0.13428		1.19206	*	0.24211	***
Rotation	-1.23708	***	-0.24328	***	1.00537	*	0.21047		-0.66928		-0.17546		0.87698	*	0.20339	**
Age	0.34675		0.08717		-0.59285	**	-0.09589	**	0.02417		0.00559		0.24879		0.06839	
College	-0.57729		-0.13033		-1.12089	**	-0.14088	**	0.55268		0.11490		-0.03796		-0.01050	
No h-school	0.23429		0.06465		1.54085	*	0.46597		1.10606		0.14555	***	0.15085		0.03906	
Farmincome	-0.19506		-0.04904		-0.08481		-0.01372		-0.03667		-0.00848		-0.12629		-0.03472	
Hhincome	0.03100		0.00779		-0.20792		-0.03363		-0.05605		-0.01296		-0.00344		-0.00095	
Riskaverse	-0.25119		-0.06302		0.58353		0.09654		-0.36182		-0.08416		-0.56872		-0.15579	
Early-adopt	-0.13734		-0.03374		0.28042		0.04862		0.20200		0.04507		0.12717		0.03428	
Stream	-0.43220		-0.10493		0.44118		0.07502		-0.62226		-0.15229		-0.36156		-0.10194	
Obs	67				66				66				68			
Pseudo R^2	0.2014				0.2188				0.2059				0.2014			

Notes: *** indicates the variable is significant at the 0.01 level; ** indicates the variable is significant at the 0.05 level; *indicates the variable is significant at the 0.10 level.

Table 4.9, Continued

Variables	Irrign. system w twr				Irrgn. water conv. pipe				Nutrient management				Pumping plant			
	Coefficient		Marg. effect		Coefficient		Marg. effect		Coefficient		Marg. effect		Coefficient		Marg. effect	
Acres	0.00049		0.00003		0.00057	*	0.00020	*	-0.00001		0.00000		0.00071	**	0.00016	**
Cash	-0.77635		-0.04426		0.17378		0.05828		0.22920		0.08695		-1.27149	**	-0.23517	***
Share	-		-		0.62839		0.18544		0.17966		0.06781		0.66090		0.18521	
Doublecrop	-1.65673	*	-0.06561	*	0.58774		0.18244		0.65632		0.23445		-0.39771		-0.07969	
Rotation	-2.04355	***	-0.10329		0.94376	**	0.28142	**	1.38206	***	0.44615	***	-0.00232		-0.00053	
Age	-0.48653		-0.03318		0.31678		0.10844		0.26943		0.10366		0.60352	**	0.13692	**
College	-0.47347		-0.02770		0.66551		0.21076	*	-0.05180		-0.01998		-1.18929	**	-0.21338	***
No h-school	-		-		-		-		0.72391		0.23960		0.81030		0.24831	
Farmincome	0.03959		0.00270		0.04216		0.01443		-0.18335		-0.07054		-0.05212		-0.01182	
Hhincome	0.67524	***	0.04604	**	-0.11072		-0.03790		0.10372		0.03990		0.10513		0.02385	
Riskaverse	-1.20203	**	-0.09111		-0.20565		-0.07050		-0.28744		-0.11036		-1.18401	***	-0.26766	**
Early-adopt	1.58837	***	0.20428	**	-0.24196		-0.08431		0.47501		0.17688		-0.06665		-0.01491	
Stream	-0.73720		-0.04796		0.21072		0.07130		0.13278		0.05091		-0.06187		-0.01396	
Obs	66				63				66				65			
Pseudo R^2	0.4043				0.2053				0.2388				0.3314			

Notes: *** indicates the variable is significant at the 0.01 level; ** indicates the variable is significant at the 0.05 level; *indicates the variable is significant at the 0.10 level.

Table 4.10: Summary Table of Statistically Significant Results (Relationship between Dependent and Independent Variables)

	Conser -vation cover	Critical area planting	Field border	Grade stbln structure	Filter strip	Grassed water-ways	Irrign. water management	Irrign. land leveling	Irrign. system w twr	Irrign. water conv. Pipe	Nutrie-nt Mngt.	Pump-ing plant
Acres							+			+		+
Cash			--	--		--	--					--
Share						--						
Doublecrop						+		+	--			
Rotation	--				--	+		+	--	+	+	
Age	+	+				--						+
College						--				+		--
No h-school				+		+	+					
Farmincome	--											
Hhincome				+					+			
Riskaverse									--			--
Early-adopt	+	+		+					+			
Stream	--			+								

Table 4.11: Results of the Multicollinearity Diagnostic Test

Variables	Variation Inflation	Condition Index
Intercept	0	1.00000
Acres	1.84504	2.41793
Cash	1.33542	2.79462
Share	1.24216	3.05001
Doublecrop	1.35072	3.14500
Rotation	1.54074	3.46376
Yearsfarm	1.18708	3.80497
Farmincome	1.19532	3.98247
Hhincome	1.53119	4.56771
Age	1.25302	5.17626
College	1.23296	5.73641
Nohs	1.29617	6.88460
Riskaverse	1.41565	8.07757
Techadoptearly	1.29622	10.47528
Stream	1.22150	21.48894

The influence of having other crops either in double-cropping or rotational arrangements on BMP adoption was mixed. Double-cropping was positively associated with the adoption of two BMPs: Grassed Waterways and Irrigation Land Leveling, but negatively associated with the adoption of an Irrigation System with Tailwater Recovery. Rotating crawfish production with other crops was positively associated with the adoption of Grassed Waterways, Irrigation Land Leveling, Irrigation Water Conveyance via a Pipeline, and Nutrient Management, but negatively associated with the adoption of Conservation Cover, Filter Strips, and Irrigation System with Tailwater Recovery. Overall, it is striking that BMP adoption is particularly associated with whether crawfish production is produced in a system with other crops, most commonly rice. The positive influences of these systems on BMPs that involve significant initial investment such as Irrigation Land Leveling and Irrigation Water Conveyance via a Pipeline is not surprising, given the investments can have positive impacts on both the rice and crawfish enterprises. Nutrient Management is likely to be particularly useful for crop production, given the greater use of fertilizer with most crops, making its use more likely in a double-crop or rotational system.

Results of demographic variables vary, depending upon BMP. AGE is positively related to the adoption of three BMPs and negative for one, College is positively related to the adoption of one BMP and negatively related with two, and lacking a High School diploma is positively related with the adoption of three BMPs. The mixed educational results differ from other BMP studies examined, where greater education generally led to greater adoption. AGE, however, has produced mixed results in previous studies, as discussed earlier with respect to Rahelizatovo and Gillespie (2004) and Kim *et al.* (2008).

Percentage of household income from the farm is significant for two BMPs, suggesting that greater financial importance of the farm to the household income increases the use of Grade Stabilization Structure and Irrigation System with Tailwater Recovery. On the other hand, a higher percentage of farm income from the crawfish operation negatively influenced Conservation Cover adoption, suggesting that farms concentrating more heavily in other farm enterprises would be the greater adopters of this BMP.

As expected, producers who considered themselves to be early technology adopters were more likely to adopt four BMPs than those who considered themselves to be late adopters. Having a stream running through the farm negatively influenced the adoption of one BMP (Conservation Cover) and positively influenced the adoption of another (Grade Stabilization Structure). Risk-averse farmers were less likely to have adopted two BMPs, Irrigation System with Tailwater Recovery and Pumping Plant, both of which would require substantial initial investments.

4.3. REASONS FOR ADOPTION / NONADOPTION

Though the probit results show the effects of a number of factors on the adoption decisions for individual BMPs, the question of a particular reason behind adoption was still unknown. To understand the reasons for adoption and non-adoption of individual BMPs, multinomial logit analysis was conducted among ten possible answer choices included in the survey. The frequencies of individual responses by farmers and their total “Yes” and “No” percentages for all 18 BMPs are presented in Table 4.12.

Total responses in adoption categories included answer choices 1-5, while those of total non-adoption responses included the answer choices 6-10. At the end, total frequencies as well as percentages of adoption and non-adoption of individual BMPs are summed. In some cases, farmers checked more than one box leading the researchers to count these as simply “yes” or “no” responses. These responses are not included in the reasons for adoption or non-adoption.

It was observed that most of the respondents answered, “It increases profit” in the “Yes” column and “It doesn’t apply to my farm” in the “No” column, but a scattered distribution of frequencies among all of the other choices was observed. For purposes of the MNL, groups of reasons were assembled together and 3 to 4 categories were prepared for the analyses. A category was required to have at least 11 observations (15% of the total) in order for it to be included as a separate choice in the MNL. Otherwise, it was aggregated with other categories. Table 4.13 showed a combination of those answer choices based on total frequencies observed.

Using SUEST results, the basic IIA assumption was violated for all BMPs except for two: Irrigation Land Leveling and Irrigation Water Conveyance via Pipelines. Therefore, only those two multinomial logit results are presented in this section.

4.3.1. Multinomial Logit Results for Irrigation Land Leveling

Table 4.14 shows multinomial logit results for Irrigation Land Leveling. The producers with larger farm size *(ACRES)* were less likely to answer “other yes” relative to “yes, it increases profit” in the case of Irrigation Land Leveling. Negative marginal effects of *DOUBLECROP* and *ROTATION* in the “no” category showed that farmers who double-cropped or farmed in a rotation are more likely to adopt Irrigation Land Leveling. The results further showed that having

Table 4.12: Adoption/Non-adoption Answer Frequencies of Individual BMPs

Answer Choices	Best Management Practices and Frequencies					
	Conservation Cover	Critical Area Planting	Field Border	Grade Stb. Structure	Filter Strip	Grassed Waterway
1: Yes, I established it because it leads to increased profit.	14	6	4	3	3	1
2: Yes, I established it because it is good for the environment.	6	6	8	3	5	5
3: Yes, I established it because I have been encouraged/required to do so.	1	2	2	1	1	1
4: Yes, I established it since it's good for long-run land productivity.	10	15	11	17	7	2
5: Yes, this practice was established by the landowner or another tenant.	0	0	1	1	0	1
6: No, I am not familiar with this practice	12	7	8	14	14	12
7: No, this doesn't apply to my farm.	13	26	24	24	26	36
8: No, this would reduce my profit.	1	0	2	0	1	1
9: No, I am still considering doing this.	3	2	2	0	3	2
10: No, I prefer not to do this.	3	2	4	3	7	5
All Yes: Those who checked in all "Yes" answer choices (1 through 5).	7	5	2	3	1	2
All No: Those who checked in all "No" answer choices (6 through 10).	0	1	2	2	3	2
"Yes" Total	38	34	28	28	17	12
"No" Total	32	38	42	43	54	58
Total	70	72	70	71	71	70
"Yes": Percentage total	54.29	47.22	40	39.44	23.94	17.14
"No": Percentage total	45.71	52.78	60	60.56	76.06	82.86

Table 4.12, Continued

Answer Choices	Best Management Practices and Frequencies					
	Irg. Water Management	Irg. Land Leveling	Irg. Storage Reservoir	Irg. Reglt. Reservoir	Irg. S. with TWR	Irg. Water C. via a Pipelines
1: Yes, I established it because it leads to increased profit.	35	30	4	6	6	22
2: Yes, I established it because it is good for the environment.	3	1	0	1	2	1
3: Yes, I established it because I have been encouraged/required to do so.	3	3	0	0	0	1
4: Yes, I established it since it's good for long-run land productivity.	6	14	1	1	2	11
5: Yes, this practice was established by the landowner or another tenant.	0	0	0	0	0	1
6: No, I am not familiar with this practice.	7	3	6	8	8	2
7: No, this doesn't apply to my farm.	5	7	46	44	43	21
8: No, this would reduce my profit.	0	0	0	0	1	0
9: No, I am still considering doing this.	0	6	5	1	2	2
10: No, I prefer not to do this.	3	2	5	7	4	3
All Yes: Those who checked in all "Yes" answer choices (1 through 5)	8	7	0	0	0	8
All No: Those who checked in all "No" answer choices (6 through 10)	0	0	2	2	2	0
"Yes" Total	55	55	5	8	10	44
"No" Total	15	18	64	62	60	28
Total	70	73	69	70	70	72
"Yes": Percentage total	78.57	75.34	7.25	11.43	14.29	61.11
"No": Percentage total	21.43	24.66	92.75	88.57	85.71	38.89

Table 4.12, Continued

Answer Choices	Best Management Practices and Frequencies					
	Nutrient Management	Pumping Plant	Range Planting	Riparian Forest Buffer	Stream-bank & Shoreline Protection	Tree/Shrub Estd.
1: Yes, I established it because it leads to increased profit.	21	12	2	0	0	1
2: Yes, I established it because it is good for the environment.	4	0	1	3	1	1
3: Yes, I established it because I have been encouraged/required to do so.	2	2	1	0	0	1
4: Yes, I established it since it's good for long-run land productivity.	8	2	3	0	0	1
5: Yes, this practice was established by the landowner or another tenant.	1	0	0	0	0	1
6: No, I am not familiar with this practice.	7	11	10	10	17	8
7: No, this doesn't apply to my farm.	18	35	39	46	40	43
8: No, this would reduce my profit.	0	0	0	0	0	0
9: No, I am still considering doing this.	0	1	2	2	2	5
10: No, I prefer not to do this.	4	3	8	7	6	7
All Yes: Those who checked in all "Yes" answer choices (1 through 5)	4	0	0	0	1	0
All No: Those who checked in all "No" answer choices (6 through 10)	1	2	2	2	2	2
"Yes" Total	40	16	7	3	2	5
"No" Total	30	52	61	67	67	65
Total	70	68	68	70	69	70
"Yes": Percentage total	57.14	23.53	10.29	4.29	2.90	7.14
"No": Percentage total	42.86	76.47	89.71	95.71	97.10	92.86

Table 4.13: Aggregation of Responses for Multinomial Logit Models

Best Management Practices and Answer Choices Codes					
Conservation Cover	**Critical Area Planting**	**Field Border**	**Grade Stb. Structure**	**Filter Strip**	**Grassed Waterway**
1	1,2,3,5	1,2,3,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5
2,3,4,5	4	4	6,8,9,10	6	6,8,9,10
6,8,9,10	6,8,9,10	6,8,9,10	7	8,9,10	7
7	7	7		7	

Irrigation Water Mngt.	Irrigation Land Leveling	Irrigation Storage Reservoir	Irrigation Regulatory Reservoir	Irrig. System with Tailwater Recovery	Irrigation Water Conveyance via a Pipelines
1	1	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1
2,3,4,5	2,3,4,5	6,8,9,10	6,8,9,10	6,8,9,10	2,3,4,5
6,7,8,9,10	6,7,8,9,10	7	7	7	6,7,8,9,10

Nutrient Management	Pumping Plant	Range Planting	Riparian Forest Buffer	Streambank & Shoreline Protection	Tree/Shrub Estd.
1	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5		1,2,3,4,5
2,3,4,5	6,,8,9,10	6,8,9,10	6,8,9,10		6,8,9,10
6,8,9,10	7	7	7		7
7					

Answer Choices

YES: 1: Yes, I established it because it leads to increased profit; **2:** Yes, I established it because it is good for the environment; **3:** Yes, I established it because I have been encouraged/required to do so; **4:** Yes, I established it since it's good for long-run land productivity; **5:** Yes, this practice was established by the landowner or another tenant.

NO: 6: No, I am not familiar with this practice; **7:** No, this doesn't apply to my farm; **8:** No, this would reduce my profit; **9:** No, I am still considering doing this, and **10:** No, I prefer not to do this.

All yes: Those who checked in all "Yes" answer choices (1 through 5); All No: Those who checked in all "No" answer choices (6 through 10)

Table 4.14: Irrigation Land Leveling, Multinomial Logit Results

Variables	Other Yes vs. Yes, It Increases Profit		No vs. Yes, It Increases Profit		Marginal Effects		
	Coefficient	Robust Std Error	Coefficient	Robust Std Error	Yes, It Increases Profit	Other Yes	No
Acres	-0.001*	0.001	0.000	0.001	0.000	0.000*	0.000
Cash	-0.252	0.959	-0.606	0.893	0.103	-0.016	-0.088
Share	-0.536	1.141	-0.924	1.021	0.168	-0.052	-0.116
Doublecrop	-0.012	1.188	-2.150	1.405	0.194	0.073	-0.266**
Rotation	0.574	1.138	-1.489	1.004	0.064	0.170	-0.234**
Age	-0.495	0.540	-0.762	0.524	0.155	-0.048	-0.107
College	-0.464	1.065	-0.031	0.865	0.058	-0.074	0.016
Farmincome	-0.437	0.283	0.069	0.227	0.045	-0.078	0.033
Hhincome	-0.048	0.342	-0.071	0.221	0.015	-0.005	-0.010
Riskaverse	-1.005	0.915	0.614	0.857	0.048	-0.200	0.152
Early-adopt	-0.835	1.041	-0.345	0.916	0.140	-0.118	-0.022
Stream	1.240	0.901	1.013	0.674	-0.273*	0.164	0.109
Constant	2.810	1.948	2.240	1.968			

Pseudo R^2 = 0.2205; Suest: Chi-square (12) = 11.57; Prob > Chi-square = 0.4809

Notes: *** indicates the variable is significant at the 0.01 level; ** indicates the variable is significant at the 0.05 level; *indicates the variable is significant at the 0.10 level.

a *STREAM* near the farm decreased the adoption rate of Irrigation Land Leveling for reason of “increase in profit”. The pseudo R-square of the model was 0.2205.

4.3.2. Multinomial Logit Results for Irrigation Water Conveyance Pipe

Table 4.15 shows the multinomial logit results for Irrigation Water Conveyance Pipe. Results show that if a farmer is *RISKAVERSE* or an early adopter *(TECHADOPTEARLY)*, he/she is less likely to adopt Irrigation Water Conveyance Pipe for other reasons relative to increase in profit. Larger farmers were less likely to adopt for reasons other than maximizing profit. Results further showed that the marginal increase in adoption of Irrigation Water Conveyance Pipe for increase in profit is positively associated with total number of *ACRES*, *SHARE* lease system and having a *COLLEGE* degree. The pseudo R-square was found to be 0.2854 in this model.

4.4. T-TEST RESULTS

The results of t-tests are presented in this section. The differences in percent adoption of individual BMPs out of both non-adoption and adoption frequencies of a particular BMP were tested and the significant differences are presented as superscripts.

4.4.1. Conservation Cover

Table 4.16 shows the adoption rates of other BMPs with respect to the adoption and non-adoption of Conservation Cover. Results show that the adoption rates of Critical Area Planting, Field Border, Grade Stabilization Structure, Filter Strips, and Range Planting among the adopters of Conservation Cover were significantly larger than those adoption rates among non-adopters of conservation cover. This suggests that these BMPs are complementarily adopted with Conservation Cover.

4.4.2. Critical Area Planting

Table 4.17 presents the adoption rates of individual BMPs with respect to the adoption and

Table 4.15: Irrigation Water Conveyance Pipe, Multinomial Logit Results

Variables	Other Yes vs. Yes, It Increases Profit		No vs. Yes, It Increase Profit		Marginal Effects		
	Coefficient	Robust Std Error	Coefficient	Robust Std Error	Yes, It Increases Profit	Other Yes	No
Acres	0.000	0.001	-0.001*	0.001	0.000*	0.000	0.000**
Cash	-1.493	1.388	-0.109	0.903	0.098	-0.132	0.034
Share	-1.155	0.993	-1.151	0.865	0.272*	-0.065	-0.207
Doublecrop	0.954	1.223	-0.922	0.926	0.067	0.178	-0.245
Rotation	0.040	1.609	-1.285	0.838	0.219	0.060	-0.278*
Age	-0.414	0.578	-0.676	0.437	0.153	-0.012	-0.141
College	-0.339	1.028	-1.436*	0.853	0.273*	0.022	-0.295**
Farmincome	-0.503	0.491	-0.149	0.204	0.058	-0.047	-0.012
Hhincome	0.408	0.347	0.346	0.271	-0.090	0.027	0.063
Riskaverse	-3.077*	1.758	-0.063	0.921	0.211	-0.355**	0.144
Early-adopt	-3.102**	1.577	-0.281	0.774	0.202	-0.250**	0.048
Stream	1.965	1.576	0.286	0.701	-0.184	0.227	-0.043
Constant	2.245	2.222	3.373	1.780			

Pseudo R^2 = 0.2854; Suest: Chi-square (12) = 11.61; Prob > Chi-square = 0.4779

Notes: *** indicates the variable is significant at the 0.01 level; ** indicates the variable is significant at the 0.05 level; *indicates the variable is significant at the 0.10 level.

non-adoption decision of Critical Area Planting. The complementarily adopted BMPs with Critical Area Planting are Conservation Cover, Field Border, Grade Stabilization Structure, Filter Strips, Irrigation Storage Reservoir, Irrigation Regulatory Reservoir, Irrigation Water Conveyance Pipe, and Range Planting.

4.4.3. Field Border

Table 4.18 presents the adoption distribution of individual BMPs among the adopters and non-adopters of Field Border. The BMPs likely to be adopted in combination with Field Border are Conservation Cover, Critical Area Planting, Filter Strips, Grassed Waterways, Irrigation Water Management, Pumping Plant, Riparian Forest Buffer, and Tree Shrub Establishment. This result further shows that most of the adopters of Field Border also adopted Irrigation Water Management and Conservation Cover; both having adoption rates of more than 71 percent.

Table 4.16: Paired T-Test of Conservation Cover with Other BMPs

Best Management Practices	Conservation Cover Non-Adoption Obs: 32	 Adoption Obs: 38
Critical Area Planting	.156^{A}	.763^{B}
Field Border	.258^{A}	.541^{B}
Grade Stabilization Structure	.187^{A}	.567^{B}
Filter Strips	.156^{A}	.324^{B}
Grassed Waterways	.156	.194
Irrigation Water Management	.709	.837
Irrigation Land Leveling	.718	.763
Irrigation Storage Reservoir	.031	.114
Irrigation Regulatory Reservoir	.062	.166
Irrigation System TWR	.093	.194
Irrigation Water Conveyance Pipe	.562	.621
Nutrient Management	.483	.648
Pumping Plant	.161	.314
Range Planting	.031^{A}	.176^{B}
Riparian Forest Buffer	.031	.055
Streambank and Shoreline Protection	.031	.027
Tree Shrub Establishment	.031	.111

Note: Superscripts ‘^{A}’ and ‘^{B}’ represent that percent non-adoption and adoption differ in 0.10 level.

Table 4.17: Paired T-Test of Critical Area Planting with Other BMPs

Best Management Practices	Critical Area Planting Non-Adoption Obs: 38	Critical Area Planting Adoption Obs: 34
Conservation Cover	$.25^{A}$	$.853^{B}$
Field Border	$.270^{A}$	$.545^{B}$
Grade Stabilization Structure	$.289^{A}$	$.515^{B}$
Filter Strips	$.131^{A}$	$.363^{B}$
Grassed Waterways	.105	.25
Irrigation Water Management	.783	.787
Irrigation Land Leveling	.736	.764
Irrigation Storage Reservoir	0^{A}	$.161^{B}$
Irrigation Regulatory Reservoir	$.026^{A}$	$.218^{B}$
Irrigation System TWR	.105	.187
Irrigation Water Conveyance Pipe	$.473^{A}$	$.757^{B}$
Nutrient Management	.486	.666
Pumping Plant	.243	.225
Range Planting	0^{A}	$.233^{B}$
Riparian Forest Buffer	.026	.062
Streambank and Shoreline Protection	.027	.031
Tree Shrub Establishment	.052	.093

Note: Superscripts ‘A’ and ‘B’ represent that percent non-adoption and adoption differ in 0.10 level.

Table 4.18: Paired T-Test of Field Border with Other BMPs

Best Management Practices	Field Border Non-Adoption Obs: 42	Field Border Adoption Obs: 28
Conservation Cover	$.425^{A}$	$.714^{B}$
Critical Area Planting	$.357^{A}$	$.643^{B}$
Grade Stabilization Structure	.309	.5
Filter Strips	0^{A}	$.571^{B}$
Grassed Waterways	$.071^{A}$	$.333^{B}$
Irrigation Water Management	$.707^{A}$	$.892^{B}$
Irrigation Land Leveling	.785	.678
Irrigation Storage Reservoir	.073	.074
Irrigation Regulatory Reservoir	.071	.185
Irrigation System TWR	.142	.148
Irrigation Water Conveyance Pipe	.619	.571
Nutrient Management	.536	.607
Pumping Plant	$.166^{A}$	$.346^{B}$
Range Planting	.075	.148
Riparian Forest Buffer	0^{A}	$.111^{B}$
Streambank and Shoreline Protection	.048	0
Tree Shrub Establishment	$.023^{A}$	$.148^{B}$

Note: Superscripts ‘A’ and ‘B’ represent that percent non-adoption and adoption differ in 0.10 level.

4.4.5. Grade Stabilization Structure

The adoption percentages of individual BMPs among the list of non-adoption and adoption categories of Grade Stabilization Structure is presented in the Table 4.19. Results show there is a very high complementary relationship between Grade Stabilization Structure and Conservation Cover, Irrigation Water Management, and Nutrient Management, all with 75% adoption. Other complementary BMPs include Critical Area Planting, Irrigation Storage Reservoir, and Pumping Plant.

Table 4.19: Paired T-Test of Grade Stabilization Structure with Other BMPs

Best Management Practices	**Grade Stabilization Structure** **Non-Adoption** **Obs: 43**	 **Adoption** **Obs: 28**
Conservation Cover	.381^{A}	.778^{B}
Critical Area Planting	.372^{A}	.607^{B}
Field Border	.326	.519
Filter Strips	.186	.321
Grassed Waterways	.116	.259
Irrigation Water Management	.720^{A}	.888^{B}
Irrigation Land Leveling	.697	.821
Irrigation Storage Reservoir	.023^{A}	.148^{B}
Irrigation Regulatory Reservoir	.069	.185
Irrigation System TWR	.069^{A}	.259^{B}
Irrigation Water Conveyance Pipe	.604	.607
Nutrient Management	.428^{A}	.785^{B}
Pumping Plant	.162^{A}	.36^{B}
Range Planting	.071	.153
Riparian Forest Buffer	.023	.074
Streambank and Shoreline Protection	.023	.038
Tree Shrub Establishment	.046	.111

Note: Superscripts '^{A}' and '^{B}' represent that percent non-adoption and adoption differ in 0.10 level.

4.4.6. Filter Strips

The adoption rates of all 17 BMPs with the adoption and non-adoption decision of Filter Strips are presented in Table 4.20. All of the adopters of Filter Strips also adopted Field Border and Irrigation Water Management. At least 50% of the adopters of Filter Strips also adopted Conservation Cover (70.5%), Critical Area Planting (70.6%), and Pumping Plant (50%). BMPs with adoption rates of less than 50% of total adopters of Filter Strips are Grassed Waterways (37.5%), Irrigation Regulatory Reservoir (25%), Range Planting (25%), Riparian Forest Buffer (12.5%) and Tree Shrub Establishment (18.7%).

Table 4.20: Paired T-Test of Filter Strips with Other BMPs

Best Management Practices	Filter Strips Non-Adoption Obs: 54	Filter Strips Adoption Obs: 17
Conservation Cover	.481^{A}	.705^{B}
Critical Area Planting	.389^{A}	.706^{B}
Field Border	.222^{A}	1^{B}
Grade Stabilization Structure	.352	.529
Grassed Waterways	.111^{A}	.375^{B}
Irrigation Water Management	.716^{A}	1^{B}
Irrigation Land Leveling	.759	.705
Irrigation Storage Reservoir	.075	.062
Irrigation Regulatory Reservoir	.074^{A}	.25^{B}
Irrigation System TWR	.129	.187
Irrigation Water Conveyance Pipe	.592	.647
Nutrient Management	.528	.705
Pumping Plant	.166^{A}	.5^{B}
Range Planting	.057^{A}	.25^{B}
Riparian Forest Buffer	.018^{A}	.125^{B}
Streambank and Shoreline Protection	.037	0
Tree Shrub Establishment	.037^{A}	.187^{B}

Note: Superscripts '^{A}' and '^{B}' represent that percent non-adoption and adoption differ in 0.10 level.

4.4.7. Grassed Waterways

Table 4.21 shows that 75% of the adopters of Grassed Waterways are also the adopters of Field Border and that 50% are also the adopters of Filter Strips. Other BMPs having higher adoption rates among the list of the adopters of Grassed Waterways than those of non-adopters include Irrigation Regulatory Reservoir, Pumping Plant, Range Planting, and Riparian Forest Buffer.

4.4.8. Irrigation Water Management

Table 4.22 presents the t-test results of the adopters of different BMPs between adopters and non-adopters of Irrigation Water Management. It was found that Field Border, Filter Strips,

Table 4.21: Paired T-Test of Grassed Waterways with Other BMPs

Best Management Practices	Grassed Waterways Non-Adoption Obs: 58	Grassed Waterways Adoption Obs: 12
Conservation Cover	.518	.583
Critical Area Planting	.414	.667
Field Border	$.316^{A}$	$.75^{B}$
Grade Stabilization Structure	.344	.583
Filter Strips	$.172^{A}$	$.5^{B}$
Irrigation Water Management	.771	.833
Irrigation Land Leveling	.724	.833
Irrigation Storage Reservoir	.070	.083
Irrigation Regulatory Reservoir	$.086^{A}$	$.25^{B}$
Irrigation System TWR	.137	.166
Irrigation Water Conveyance Pipe	.620	.5
Nutrient Management	.526	.75
Pumping Plant	$.196^{A}$	$.416^{B}$
Range Planting	$.071^{A}$	$.25^{B}$
Riparian Forest Buffer	0^{A}	$.25^{B}$
Streambank and Shoreline Protection	.035	0
Tree Shrub Establishment	.051	.166

Note: Superscripts ‘A’ and ‘B’ represent that percent non-adoption and adoption differ in 0.10 level.

Table 4.22: Paired T-Test of Irrigation Water Management with Other BMPs

Best Management Practices	Irrigation Water Management Non-Adoption Obs: 15	Irrigation Water Management Adoption Obs: 55
Conservation Cover	.40	.585
Critical Area Planting	.467	.473
Field Border	$.2^{A}$	$.463^{B}$
Grade Stabilization Structure	$.2^{A}$	$.436^{B}$
Filter Strips	0^{A}	$.309^{B}$
Grassed Waterways	.133	.185
Irrigation Land Leveling	$.533^{A}$	$.8^{B}$
Irrigation Storage Reservoir	0	.094
Irrigation Regulatory Reservoir	0	.148
Irrigation System TWR	0^{A}	$.185^{B}$
Irrigation Water Conveyance Pipe	.6	.618
Nutrient Management	$.214^{A}$	$.672^{B}$
Pumping Plant	$.066^{A}$	$.288^{B}$
Range Planting	.071	.113
Riparian Forest Buffer	.066	.037
Streambank and Shoreline Protection	0	.037
Tree Shrub Establishment	0	.092

Note: Superscripts ‘A’ and ‘B’ represent that percent non-adoption and adoption differ in 0.10 level.

Grade Stabilization Structure, Irrigation Land Leveling, Irrigation System TWR, Nutrient Management, and Pumping Plant are more inclined to be adopted with Irrigation Water Management. The 80% of the adopters of Irrigation Water Management also adopting Irrigation Land Leveling could be because of the close association of these BMPs. Some of the other BMPs can be independent of the adoption decision of Irrigation Water Management, and therefore may not have shown significant association.

4.4.9. Irrigation Land Leveling

Table 4.23 outlines the adoption distribution of 17 BMPs with respect to the Irrigation Land Leveling adoption decision. Results showed 84.6% of producers adopting Irrigation Land Leveling also adopted Irrigation Water Management, which is very consistent with the previous explanation that these two BMPs are closely related in adoption decision. Two other BMPs complementarily adopted with Irrigation Land Leveling are Irrigation Water Conveyance Pipe (66.7%) and Nutrient Management (66%).

4.4.10. Irrigation Storage Reservoir

Table 4.24 shows the adoption rates of individual BMPs among the adopters and non-adopters of Irrigation Storage Reservoir. Results show all of the adopters of Irrigation Storage Reservoir also adopted Critical Area Planting, and Irrigation Regulatory Reservoir. Eighty percent of the adopters of Irrigation Storage Reservoir also adopted Grade Stabilization Structure and 60% adopted Irrigation System Tail Water Recovery. Less than 50% of the adopters of Irrigation Storage Reservoir adopted Riparian Forest Buffer (20%), Streambank and Shoreline Protection (20%) and Tree Shrub Establishment (40%).

4.4.11. Irrigation Regulatory Reservoir

Table 4.25 presents the adoption rates of different BMPs by adoption and non-adoption decisions of Irrigation Regulatory Reservoir. Results showed almost 90% of the adopters of

Table 4.23: Paired T-Test of Irrigation Land Leveling with Other BMPs

Best Management Practices	Irrigation Land Leveling Non-Adoption Obs: 18	Adoption Obs: 55
Conservation Cover	.50	.558
Critical Area Planting	.444	.481
Field Border	.5	.365
Grade Stabilization Structure	.277	.433
Filter Strips	.277	.226
Grassed Waterways	.111	.192
Irrigation Water Management	.611^{A}	.846^{B}
Irrigation Storage Reservoir	0	.098
Irrigation Regulatory Reservoir	.166	.096
Irrigation System TWR	.111	.153
Irrigation Water Conveyance Pipe	.444^{A}	.667^{B}
Nutrient Management	.294^{A}	.660^{B}
Pumping Plant	.166	.26
Range Planting	.117	.098
Riparian Forest Buffer	0	.057
Streambank and Shoreline Protection	0	.039
Tree Shrub Establishment	.111	.057

Note: Superscripts '^{A}' and '^{B}' represent that percent non-adoption and adoption differ in 0.10 level.

Table 4.24: Paired T-Test of Irrigation Storage Reservoir with Other BMPs

Best Management Practices	Irrigation Storage Reservoir Non-Adoption Obs: 64	Adoption Obs: 5
Conservation Cover	.50	.80
Critical Area Planting	.406^{A}	1^{B}
Field Border	.397	.4
Grade Stabilization Structure	.359^{A}	.8^{B}
Filter Strips	.234	.2
Grassed Waterways	.171	.20
Irrigation Water Management	.761	1
Irrigation Land Leveling	.718	1
Irrigation Regulatory Reservoir	.046^{A}	1^{B}
Irrigation System TWR	.109^{A}	.6^{B}
Irrigation Water Conveyance Pipe	.578	.8
Nutrient Management	.539	.8
Pumping Plant	.225	.4
Range Planting	.095	.25
Riparian Forest Buffer	.031^{A}	.2^{B}
Streambank and Shoreline Protection	.015^{A}	.2^{B}
Tree Shrub Establishment	.046^{A}	.4^{B}

Note: Superscripts '^{A}' and '^{B}' represent that percent non-adoption and adoption differ in 0.10 level.

Irrigation Regulatory Reservoir also adopted Critical Area Planting and that 50% adopted Filter Strips and Irrigation System TWR. Other BMPs positively associated with the adoption decision of Irrigation Regulatory Reservoir were Grassed Waterways, Irrigation Storage Reservoir, Streamline and Shoreline Protection, and Tree Shrub Establishment.

Table 4.25: Paired T-Test of Irrigation Regulatory Reservoir with Other BMPs

Best Management Practices	Irrigation Regulatory Reservoir Non-Adoption Obs: 62	Adoption Obs: 8
Conservation Cover	.50	.75
Critical Area Planting	.403^{A}	.875^{B}
Field Border	.361	.625
Grade Stabilization Structure	.354	.625
Filter Strips	.193^{A}	.5^{B}
Grassed Waterways	.145^{A}	.375^{B}
Irrigation Water Management	.754	1
Irrigation Land Leveling	.758	.625
Irrigation Storage Reservoir	0^{A}	.625^{B}
Irrigation System TWR	.096^{A}	.5^{B}
Irrigation Water Conveyance Pipe	.612	.5
Nutrient Management	.557	.625
Pumping Plant	.216	.375
Range Planting	.098	.142
Riparian Forest Buffer	.032	.125
Streambank and Shoreline Protection	.016^{A}	.125^{B}
Tree Shrub Establishment	.048^{A}	.25^{B}

Note: Superscripts ‘A’ and ‘B’ represent that percent non-adoption and adoption differ in 0.10 level.

4.4.12. Irrigation System TWR

Table 4.26 shows that all of the adopters of Irrigation System TWR also adopted Irrigation Water Management, 70% adopted a Grade Stabilization Structure, 30% adopted an Irrigation Storage Reservoir, 40% adopted an Irrigation Regulatory Reservoir, 60% adopted a Pumping Plant and 30% adopted Tree Shrub Establishment.

4.4.13. Irrigation Water Conveyance Pipe

Table 4.27 shows the adoption rate of the 17 BMPs among a list of adopters and non-adopters of Irrigation Water Conveyance Pipe. Results show that Irrigation Water Conveyance

Pipe has a complementary relationship with Critical Area Planting, Irrigation Land Leveling, and Nutrient Management.

4.4.14. Nutrient Management

The adoption rates of BMPs among adopters and non-adopters of Nutrient Management are presented in Table 4.28. The rates of adoption are highest for Irrigation Water Management (92.5%) and Irrigation Land Leveling (87.5%), while 55% of the producers adopting Grade Stabilization Structure also adopted Nutrient Management. Other BMPs which are also complementarily adopted with Nutrient Management are Irrigation Water Conveyance Pipe (70%), Pumping Plant (32.4%), Range Planting (15.7%) and Tree Shrub Establishment (12.8%).

4.4.15. Pumping Plant

Table 4.29 shows the adoption rates of BMPs among the list of adopters and non-adopters of Pumping Plant. More than 90% of the producers who adopt Pumping Plant also adopted Irrigation Water Management, which is likely because of the close complementarities of these two BMPs. Other BMPs adopted together with the Pumping Plant are Field Border, Grade Stabilization Structure, Filter Strips, Grassed Waterways, and Irrigation System TWR. Results further suggest that 75% of the adopters of Pumping Plant also adopt Nutrient Management.

4.4.16. Range Planting

T-test results of the adoption rates of 17 BMPs among the adopters and non-adopters of Range Planting are shown in the Table 4.30. Results show that all of the adopters of Range Planting also adopted Critical Area Planting and 85.7% adopted Conservation Cover. Moreover, Filter Strips, Grassed Waterways, Nutrient Management, Pumping Plant, Riparian Forest Buffer, and Tree Shrub Establishment were also complementarily associated with the adoption decision of Range Planting.

Table 4.26: Paired T-Test of Irrigation System TWR with Other BMPs

Best Management Practices	Irrigation System TWR Non-Adoption Obs: 60	 Adoption Obs: 10
Conservation Cover	.50	.70
Critical Area Planting	.433	.6
Field Border	.389	.4
Grade Stabilization Structure	.333[A]	.7[B]
Filter Strips	.216	.3
Grassed Waterways	.166	.20
Irrigation Water Management	.745[A]	1[B]
Irrigation Land Leveling	.733	.8
Irrigation Storage Reservoir	.033[A]	.30[B]
Irrigation Regulatory Reservoir	.066[A]	.4[B]
Irrigation Water Conveyance Pipe	.6	.6
Nutrient Management	.542	.7
Pumping Plant	.172[A]	.6[B]
Range Planting	.084	.222
Riparian Forest Buffer	.033	.1
Streambank and Shoreline Protection	.016	.1
Tree Shrub Establishment	.033[A]	.3[B]

Note: Superscripts ‘A’ and ‘B’ represent that percent non-adoption and adoption differ in 0.10 level.

Table 4.27: Paired T-Test of Irrigation Water Conveyance Pipe with Other BMPs

Best Management Practices	Irrigation Water Conveyance Pipe Non-Adoption Obs: 28	 Adoption Obs: 44
Conservation Cover	.50	.561
Critical Area Planting	.286[A]	.581[B]
Field Border	.429	.381
Grade Stabilization Structure	.392	.395
Filter Strips	.214	.255
Grassed Waterways	.214	.143
Irrigation Water Management	.777	.790
Irrigation Land Leveling	.642[A]	.818[B]
Irrigation Storage Reservoir	.035	.097
Irrigation Regulatory Reservoir	.142	.095
Irrigation System TWR	.142	.142
Nutrient Management	.444[A]	.651[B]
Pumping Plant	.142	.3
Range Planting	.035	.15
Riparian Forest Buffer	0	.071
Streambank and Shoreline Protection	0	.048
Tree Shrub Establishment	.071	.071

Note: Superscripts ‘A’ and ‘B’ represent that percent non-adoption and adoption differ in 0.10 level.

Table 4.28: Paired T-Test of Nutrient Management with Other BMPs

Best Management Practices	Nutrient Management Non-Adoption Obs: 30	Nutrient Management Adoption Obs: 40
Conservation Cover	.448	.615
Critical Area Planting	.367	.55
Field Border	.367	.436
Grade Stabilization Structure	.2^{A}	.55^{B}
Filter Strips	.166	.3
Grassed Waterways	.10	.231
Irrigation Water Management	.620^{A}	.925^{B}
Irrigation Land Leveling	.6^{A}	.875^{B}
Irrigation Storage Reservoir	.033	.105
Irrigation Regulatory Reservoir	.1	.128
Irrigation System TWR	.1	.179
Irrigation Water Conveyance Pipe	.5^{A}	.7^{B}
Pumping Plant	.133^{A}	.324^{B}
Range Planting	.034^{A}	.157^{B}
Riparian Forest Buffer	0	.076
Streambank and Shoreline Protection	0	.052
Tree Shrub Establishment	0^{A}	.128^{B}

Note: Superscripts '^{A}' and '^{B}' represent that percent non-adoption and adoption differ in 0.10 level.

Table 4.29: Paired T-Test of Pumping Plant with Other BMPs

Best Management Practices	Pumping Plant Non-Adoption Obs: 52	Pumping Plant Adoption Obs: 16
Conservation Cover	.48	.688
Critical Area Planting	.462	.438
Field Border	.327^{A}	.563^{B}
Grade Stabilization Structure	.307^{A}	.562^{B}
Filter Strips	.134^{A}	.437^{B}
Grassed Waterways	.134^{A}	.312^{B}
Irrigation Water Management	.725^{A}	.937^{B}
Irrigation Land Leveling	.711	.812
Irrigation Storage Reservoir	.058	.125
Irrigation Regulatory Reservoir	.096	.187
Irrigation System TWR	.076^{A}	.375^{B}
Irrigation Water Conveyance Pipe	.538	.75
Nutrient Management	.490^{A}	.75^{B}
Range Planting	.06^{A}	.25^{B}
Riparian Forest Buffer	0^{A}	.187^{B}
Streambank and Shoreline Protection	.019	.062
Tree Shrub Establishment	.019^{A}	.25^{B}

Note: Superscripts '^{A}' and '^{B}' represent that percent non-adoption and adoption differ in 0.10 level.

Table 4.30: Paired T-Test of Range Planting with Other BMPs

Best Management Practices	Range Planting Non-Adoption Obs: 61	Range Planting Adoption Obs: 7
Conservation Cover	.475^{A}	.857^{B}
Critical Area Planting	.377^{A}	1^{B}
Field Border	.383	.571
Grade Stabilization Structure	.360	.571
Filter Strips	.196^{A}	.571^{B}
Grassed Waterways	.147^{A}	.428^{B}
Irrigation Water Management	.783	.857
Irrigation Land Leveling	.754	.714
Irrigation Storage Reservoir	.05	.142
Irrigation Regulatory Reservoir	.098	.142
Irrigation System TWR	.114	.285
Irrigation Water Conveyance Pipe	.557	.857
Nutrient Management	.533^{A}	.857^{B}
Pumping Plant	.203^{A}	.571^{B}
Riparian Forest Buffer	.016^{A}	.285^{B}
Streambank and Shoreline Protection	.016	0
Tree Shrub Establishment	.049^{A}	.285^{B}

Note: Superscripts '^{A}' and '^{B}' represent that percent non-adoption and adoption differ in 0.10 level.

4.4.17. Riparian Forest Buffer

Table 4.31 shows that all of the adopters of Riparian Forest Buffer also adopted Field Border, Filter Strips, Grassed Waterways, and Irrigation Storage Reservoir. Other BMPs complimentarily adopted with Riparian Forest Buffer were: Pumping Plant, Range Planting, and Tree Shrub Establishment.

4.4.18. Streambank and Shoreline Protection

Table 4.32 shows the adoption rates of 17 BMPs by the adopters and non-adopters of Streambank and Shoreline Protection. Likely because of the low adoption rate of Streambank and Shoreline Protection, the adoption distribution of most of the BMPs was practically unfeasible. Only two BMPs, Irrigation Storage Reservoir and Irrigation Regulatory Reservoir, were found to be complementarily adopted with Streambank and Shoreline Protection.

4.4.19. Tree Shrub Establishment

Table 4.33 shows the adoption of different BMPs with respect to the adoption and non-adoption of Tree Shrub Establishment. Although the adoption rate of Tree Shrub Establishment was very small as compared to the most of the other BMPs, Field Border, Filter Strips, Irrigation Storage Reservoir, Irrigation Regulatory Reservoir, Irrigation System TWR, Nutrient Management, Pumping Plant, Range Planting, and Riparian Forest Buffer were found to be adopted with Tree Shrub Establishment.

Table 4.31: Paired T-Test of Riparian Forest Buffer with Other BMPs

Best Management Practices	Riparian Forest Buffer Non-Adoption Obs: 67	Riparian Forest Buffer Adoption Obs: 3
Conservation Cover	.523	.667
Critical Area Planting	.448	.667
Field Border	.364^{A}	1^{B}
Grade Stabilization Structure	.373	.667
Filter Strips	.208^{A}	.666^{B}
Grassed Waterways	.134^{A}	1^{B}
Irrigation Water Management	.787	.666
Irrigation Land Leveling	.731	1
Irrigation Storage Reservoir	.060^{A}	.333^{B}
Irrigation Regulatory Reservoir	.104	.333
Irrigation System TWR	.134	.333
Irrigation Water Conveyance Pipe	.582	1
Nutrient Management	.545	1
Pumping Plant	.2^{A}	1^{B}
Range Planting	.076^{A}	.667^{B}
Streambank and Shoreline Protection	.030	0
Tree Shrub Establishment	.044^{A}	.666^{B}

Note: Superscripts ‘^{A}’ and ‘^{B}’ represent that percent non-adoption and adoption differ in 0.10 level.

Table 4.32: Paired T-Test of Streambank and Shoreline Protection with Other BMPs

Best Management Practices	Streambank and Shoreline Protection Non-Adoption Obs: 67	Adoption Obs: 2
Conservation Cover	.530	.50
Critical Area Planting	.463	.50
Field Border	.409	0
Grade Stabilization Structure	.373	.5
Filter Strips	.238	0
Grassed Waterways	.179	0
Irrigation Water Management	.772	1
Irrigation Land Leveling	.731	1
Irrigation Storage Reservoir	.060[A]	.50[B]
Irrigation Regulatory Reservoir	.104[A]	.5[B]
Irrigation System TWR	.134	.5
Irrigation Water Conveyance Pipe	.582	1
Nutrient Management	.545	1
Pumping Plant	.230	.5
Range Planting	N/A	N/A
Riparian Forest Buffer	.044	0
Tree Shrub Establishment	.074	0

Note: Superscripts ‘A’ and ‘B’ represent that percent non-adoption and adoption differ in 0.10 level.

Table 4.33: Paired T-Test of Tree Shrub Establishment with Other BMPs

Best Management Practices	Tree Shrub Establishment Non-Adoption Obs: 65	Adoption Obs: 5
Conservation Cover	.507	.80
Critical Area Planting	.446	.60
Field Border	.359[A]	.8[B]
Grade Stabilization Structure	.369	.6
Filter Strips	.2[A]	.6[B]
Grassed Waterways	.153	.40
Irrigation Water Management	.765	1
Irrigation Land Leveling	.753	.6
Irrigation Storage Reservoir	.046[A]	.40[B]
Irrigation Regulatory Reservoir	.092[A]	.4[B]
Irrigation System TWR	.107[A]	.6[B]
Irrigation Water Conveyance Pipe	.6	.6
Nutrient Management	.531[A]	1[B]
Pumping Plant	.190[A]	.8[B]
Range Planting	.079[A]	.4[B]
Riparian Forest Buffer	.015[A]	.4[B]
Streambank and Shoreline Protection	.031	0

Note: Superscripts ‘A’ and ‘B’ represent that percent non-adoption and adoption differ in 0.10 level.

CHAPTER 5

SUMMARY AND CONCLUSIONS

Today, people are growing ever more concerned about health and environmental issues. Not only industry, but also the increased commercialization of agriculture has been a threat to environmental deterioration in cases where proper management has not been implemented. Water quality management, one of the major environmental issues, has been a top concern of US policy makers since establishment of the Water Pollution Control Act in 1948. Since then, a number of environmental programs have been administered throughout the US to restore and maintain water quality. Besides federal and state legislation, BMPs, site specific management tools, are also considered to be environmentally and economically beneficial to agriculture.

In Louisiana, there are a number of programs to encourage farmers to adopt BMPs since adoption is a voluntary practice. Since Louisiana is the leading crawfish production state in the US, the wastewater generated from crawfish production is a challenging issue. Several programs such as the Environmental Quality Incentive Program, Conservation Security Program, Grazing Lands Conservation Initiative, Grassland Reserve Program, Wildlife Habitat Incentives Program Plan, Wetland Reserve Program, and others are among a number of established conservation programs used by Louisiana producers. Previous studies have suggested that farmer adoption of technology is affected by demographic, socioeconomic, attitudinal, and institutional factors, as well as level of information and other farm-related factors that have direct or indirect impacts on farmers' decision making processes.

This study investigated the adoption of 18 NRCS cost share eligible BMPs in the Louisiana crawfish industry. The major objectives of this study are: to determine the current efforts to contain water quality degradation, including regulatory measures, research and educational programs; to assess the extent of current adoption of BMPs in the Louisiana crawfish industry; to determine the effects of demographic, socioeconomic and farm characteristics on crawfish producers' decisions to adopt specific BMPs; to determine reasons for adoption and non-adoption of BMPs in the Louisiana crawfish Industry; and to determine the relationship of the adoption decision of one BMP with that of another.

A mail survey, based on Dillman's Total Design Method, was sent to 770 Louisiana crawfish producers in Fall, 2008. Despite a total number of four contacts made with farmers, only a 15% adjusted response rate was achieved. Though the response rate was somewhat disappointing for a producer survey, several individuals who work closely within or with this industry were rather enthusiastic about the return rate, given past experiences in collecting data from the population. This population has likely been surveyed less than other farm populations and has been less likely to participate in government farm programs since there is no crawfish specific program.

Most of the responding farmers were between 45 and 60 years of age, with 29% holding a 4-year college degree. Most had been farming crawfish for 8 to 10 years (27%) while a major portion of population did not hold off-farm job. A total of 63 percent of respondents did not own at least some of the land they farmed with most of the farmers renting land under a cash lease system. The percent of farm income from crawfish and household income from the farm was rather low (1-19%). Fifty percent of the producers characterized themselves as risk averse, and 38% responded that they adopt new technology along with most of the other producers.

5.1. Summary of Results

The adoption rate of individual BMPs varied widely from 3% (Streambank and Shoreline Protection), to 79% (Irrigation Water Management). A typical producer is not always expected to adopt all of the BMPs, but he/she can choose a number of BMPs from a list based on suitability and applicability to the farm. Producers were inclined to adopt selective Irrigation related BMPs which could be because of the immediate necessity while establishing a crawfish pond. The highest adoption rates (>60%) were observed for Irrigation Water Management, Irrigation Land Leveling, and Irrigation Water Conveyance via Pipeline. Best Management Practices Irrigation Storage Reservoir, Irrigation Regulating Reservoir, and Irrigation System Tail Water Recovery had low rates of adoption. This could be because of the larger initial cost and/or non-applicability in the production system. From the list of BMPs requiring establishment of grass-vegetation, Conservation Cover had the highest rate of adoption (54%), showing a relatively lower preference of farmers for perennial management practices.

Of the 18 BMPs, those with total "yes" responses of greater than 10 out of the total sample size of 75 (>13%) were considered for further probit analysis. Thus, a total of 12 BMPs were selected, including Conservation Cover, Critical Area Planting, Field Border, Grade Stabilization Structure, Filter Strips, Grassed Waterway, Irrigation Water Management, Irrigation Land Leveling, Irrigation System with Tail Water Recovery, Irrigation Water Conveyance via Pipe, Nutrient Management, and Pumping Plant.

Considering the adoption decision of an individual BMP to be a function of a set of 13 independent variables, probit analysis was conducted for all 12 BMPs separately. A number of factors were found to affect producers' adoption decisions. Consistent with several previous studies, the more total acres of land the producer farms, the greater is the adoption rate. Producers without a high-school diploma, or who had a higher percentage of household income from farming were greater adopters of BMPs. Moreover, producers considering themselves to be early adopters of technology were greater adopters of BMPs. Producers using cash or share leases, with greater percentage of farm income from crawfish, and those considering themselves as risk averse, were lower adopters. Some other factors such as whether a farm utilizes a double crop or rotational production system, age, farmer holding a college degree, and having a stream flowing through the farm showed mixed effects on the adoption decision. Policy makers can benefit from the knowledge that higher adopters of BMPs in the Louisiana crawfish industry are the owners of larger farms with greater percentages of household income from the farm.

Moreover, further analysis of the reasons for adoption or non-adoption was conducted by grouping answer choices into 3 to 4 categories. Individual frequencies were summed within one category and Multinomial Logit runs were made. The pre-requisite IIA assumption was violated for all of the BMPs except for two: Irrigation Land Leveling and Irrigation Water Conveyance via a Pipe. Results suggested that producers with larger farm acreage were more likely to have a perception that BMP adoption increased their profit. Adopters of Irrigation Land Leveling with a double-cropped or rotational system, are more likely to have done so for reasons other than increasing profit. Larger farmers were less likely to adopt Irrigation Water Conveyance Pipe for reasons of maximizing profit.

The complementarities of BMP adoption were tested using a t-test. The differences in percentage of adoption of individual BMPs using both non-adoption and adoption frequencies of each of the other BMPs were analyzed. Results suggest that Conservation Cover, Critical Area Planting, and Grade Stabilization Structure are complementary with each other; i.e. the adoption decision of one BMP is also associated with that of another. Further, Grade Stabilization Structure is also complementary with a number of irrigation system-related BMPs such as Irrigation Water Management, Irrigation Storage Reservoir, and Irrigation System Tail Water Recovery, suggesting a requirement of a Grade Stabilization Structure for proper water management. Filter Strips were adopted with a number of other BMPs requiring the establishment of grass-vegetation. This suggests that such BMPs are closely associated in farmer adoption decisions.

5.2. Conclusions

This study provides perhaps the first comprehensive analysis of adoption of BMPs in the Louisiana crawfish industry. Further, it seeks to determine the reasons for adoption and non-adoption of BMPs, as well as complementary relationships among BMPs. Several demographic, diversification, attitudinal, and farm characteristics were found to affect farmer adoption decisions.

(1) There is a greater inclination of farmers to adopt irrigation-related BMPs as compared to BMPs requiring establishment and management of perennial vegetation. Moreover, most of the farmers consider their farms to be non-erodible; it was thus expected to find lower adoption rates of BMPs targeted to control erosion.

(2) Larger-scale crawfish farms that are able to achieve greater amounts of household income from the farm and own a greater percentage of the land they farm are the greater BMP adopters. Further, farmers leasing their land either in cash or share leases are lower adopters of BMPs. Most of the farmers have adopted BMPs for reasons of increasing profit, or raising long run productivity, but very few of them are required/encouraged to do so. Further, unfamiliarity and perception of non-applicability are the major two reasons of non-adoption of BMPs in the crawfish industry. Further implementation of policies (EQIP, etc.) to induce landowners to establish suitable BMPs may also cause landowners to require tenants to do so.

(3) Although multinomial logit analyses for possible reasons of adoption and non-adoption were valid only for two BMPs; Irrigation Land Leveling and Irrigation Water Conveyance Pipe, results from these two BMPs suggest that the reasons for adoption or non-adoption can vary among individual BMPs due to the level of knowledge farmers have about the BMP and its suitability to the farm. Certain

extension programs targeting environmental awareness can be promoted so that familiarity of suitable BMPs would be increased.

(4) Results further provide a consistent message that farmer decisions are interrelated. Adoption of a BMP can have positive or negative effect on the adoption decision of another. Farmers choose a set of practices that are applicable to their farm, and/or profitable in long run production system.

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APPENDIX A
"SURVEY AND COMPLEMENTARY DOCUMENTS SENT TO THE LOUISIANA CRAWFISH PRODUCERS"

“FIRST CORRESPONDENCE SENT TO THE CRAWFISH PRODUCERS”

October 20, 2008

PAULETTE & CRAIG ADAM
ADAM FARMS
6113 ANTLER RD
KAPLAN, LA 70548

Dear PAULETTE & CRAIG ADAM:

The crawfish industry benefits from having accurate, up-to-date estimates of its production costs, whether for reasons of determining disaster payments after a hurricane, farmers’ use in obtaining loans, or for use as a benchmark in comparing individual farm costs with those of industry. The LSU Agricultural Center provides annual estimates of farm production costs. To provide these estimates, however, we must depend upon the willingness of farmers like you to provide data on their production practices. We are conducting a study of production practices in crawfish farming to ensure continued accuracy of our cost estimates and to determine perceptions of best management practices commonly used in the industry.

Your farm has been chosen as one from which farmers are being asked to provide information about their crawfish production practices. In order for the results to truly represent the industry, it is important that each questionnaire be completed and returned. We would like the individual with primary decision-making authority for the crawfish operation to complete the survey.

Summary results of this study will be made available to farmers and other stakeholders in the crawfish industry. Updated production cost estimates will be published annually and made available on the LSU Agricultural Center website: www.lsuagcenter.com.

All responses will be kept **strictly confidential and will not be traced back to any individual.** The questionnaire has an identification number (at the bottom of the cover page) for mailing purposes only. This is so that we can check your name off of the mailing list when your questionnaire is returned. Your name will never be placed on the questionnaire.

If you no longer farm crawfish, please indicate this on the questionnaire and return it to us. We expect it will take about **30 minutes** to fill out the questionnaire.

I would be most happy to answer any questions you might have. Please write or call. The telephone number is (225) 578-2759 and my e-mail address is jgillespie@agcenter.lsu.edu.

Thank you very much for helping with this important study.

Sincerely,

Jeffrey M. Gillespie, Ph.D.
Martin D. Woodin Endowed Professor

“FIRST POSTCARD REMINDER SENT TO THE CRAWFISH PRODUCERS”

October 30, 2008

Dear Crawfish Producer:

Last week, a questionnaire requesting information about your crawfish production system was mailed to you. If you have already completed and returned it, please accept my sincere thanks and disregard this reminder.

If you have not responded, please do so today. It is highly important that your questionnaire be completed and returned so that study results will truly represent the production characteristics of the crawfish industry. If by some chance you did not receive the questionnaire or it has been misplaced, please call or e-mail. We will gladly mail you another one. Thank you!

Sincerely,

Jeffrey Gillespie
Martin D. Woodin Endowed Professor
(225) 578-2759

“SECOND CORRESPONDENCE SENT TO THE CRAWFISH PRODUCERS”

November 7, 2008

PAULETTE & CRAIG ADAM
ADAM FARMS
6113 ANTLER RD
KAPLAN, LA 70548

Dear PAULETTE & CRAIG ADAM:

About two weeks ago, I sent you a questionnaire regarding your crawfish production system, requesting that you fill it out and return it. As of today, we have not yet received your completed questionnaire. I am writing to you again because of the importance of each survey to the usefulness of this study. The reliability of the study depends upon the participation of crawfish producers such as you.

The information gathered in this survey will help us in estimating annual costs of production for the crawfish industry. These production cost estimates may be used by farmers in obtaining loans or for comparison purposes, or by policymakers in determining disaster payments after a hurricane. As you can see, having accurate estimates of industry cost of production is very beneficial to the industry. Crawfish industry production cost estimates are made available via the LSU Agricultural Center website, www.lsuagcenter.com.

All responses will be kept **strictly confidential and will not be traced back to any individual.** The questionnaire has an identification number (at the top of the cover page) for mailing purposes only. This is so that we can check your name off of the mailing list when your questionnaire is returned. Your name will never be placed on the questionnaire.

In the event that your questionnaire has been misplaced, a replacement is enclosed. If you have already responded to the survey and we haven’t yet received your response, please accept our sincerest thanks.

I would be most happy to answer any questions you might have. Please write or call. The telephone number is (225) 578-2759 and my e-mail address is jgillespie@agcenter.lsu.edu

We greatly appreciate your cooperation.

Sincerely,

Jeffrey M. Gillespie, Ph. D.
Martin D Woodin Endowed Professor

“SECOND POSTCARD REMINDER SENT TO THE CRAWFISH PRODUCERS”

November 20, 2008

Dear Crawfish Producer:

I am writing to you about our study of Louisiana Crawfish Production Systems, as we have not yet received your completed questionnaire. Though the number of questionnaires returned is encouraging, our ability to accurately estimate crawfish production costs depends upon you and others who have not yet responded.

Production cost estimates are of value to farmers for numerous reasons, such as for use in obtaining loans. They can also be useful when disaster strikes and farm losses result. It is for these reasons that I send this 3rd reminder. May I urge you to complete and return the questionnaire? *If you have already returned the questionnaire but we haven’t yet received it, please disregard this note and accept my sincerest thanks.* Your contributions to this study are greatly appreciated.

Sincerely,

Jeffrey M. Gillespie
Martin D Woodin Endowed Professor
(225) 578-2759

“SURVEY USED TO COLLECT THE DATA”

A Survey of Louisiana Crawfish Production Systems

LSU AgCenter
Research & Extension

Your responses will be kept strictly confidential. Thank you for your time!

1. Did you produce crawfish during the 2007-2008 season on your farm? ☐ Yes ☐ No

If you answered "Yes" to question 1, please proceed to question 2. If you answered "No" to question 1, please discontinue the questionnaire, place it in the enclosed postage-paid envelope, and mail it back to us.

2. How many acres of land are included in your entire farm operation including both owned and leased?_______acres.

3. Do you own all of the land you raise crawfish on? ☐ Yes ☐ No
If you answered "Yes", then please skip to question 4; if you answered "No," then please answer A-E.

   A. Approximately what percentage of your total crawfish land do you rent?
   ☐ 1% - 20% ☐ 21% - 40% ☐ 41% - 60% ☐ 61% - 80% ☐ ≥81%

   B. What is the percentage of the pumping cost that the landlord pays? ___________%
   (If different across tracts, then provide an "average" %.)

   C. Is this a cash lease or a share lease? ☐ Cash Lease ☐ Share Lease ☐ Combination

   D. If you answered "Cash Lease" or "Combination" to 'C', then what is the annual rental rate per acre?_______$/acre.
   (If different across tracts, then provide an "average" annual rental rate/acre.)

   E. If you answered "Share Lease" or "Combination" to 'C', then what is the percentage of the live crawfish you are providing the landlord as payment? ______% **(If different across tracts, then provide an "average" %.)**

4. On your farm, including both owned and rented land, how many acres do you operate in each of the following production systems? **(Please fill in the blanks.)**

Acres (Fill In) **Production System and General Description**

___________ ***Rice-Crawfish Double-Crop***: Every year, rice and crawfish produced in the same field. *Generally,* in late spring, rice planted; late summer, rice harvested; mid-fall, field re-flooded; fall-early spring, crawfish harvested, followed by pond draining and replanting of rice.

___________ ***Rice-Crawfish-Fallow Rotation***: Rice produced 1st year, followed by crawfish, and field left fallow 2nd year. *Generally,* in spring, rice planted; early summer, crawfish stocked; late summer, field drained and rice harvested; mid-fall, rice field re-flooded; late winter-spring, crawfish harvested; late summer-spring, land fallow; spring, rice replanted.

___________ ***Rice-Crawfish-Soybeans Rotation***: Rice produced 1st year, followed by crawfish, and soybeans produced 2nd year. *Generally*, in spring, rice planted; early summer, crawfish stocked; late summer, field drained and rice harvested; mid-fall, rice field re-flooded; late winter-spring, crawfish harvested; late spring-early summer, soybeans planted; fall, soybeans harvested; late fall-early spring, field fallow; spring, rice planted.

___________ ***Single-crop Crawfish with Rice Forage***: Continuous crawfish where rice is planted, but not harvested.

___________ ***Single-crop Crawfish with Other Planted Forage***: Continuous crawfish with sorghum-sudangrass, grain sorghum, or another non-rice forage crop.

___________ ***Single-crop Crawfish with Non-planted Forage Crop***: Continuous crawfish without rice or other planted crop production.

5. (Please answer ***only*** if you produce under any of the production systems listed above besides or in addition to the three ***Single-crop Crawfish*** systems. Otherwise, proceed to question 7.) As the crawfish operator, are you also the individual who produces the rotation crop (rice, soybeans, or other crops)? Please answer with respect to the majority of your land that is in rotation. ☐ Yes **(Please go to question 7)** ☐ No **(Please go to question 6)**

6. If you answered "No" to question 5, which of the following best describes your relationship with the individual who produces the rotation crop. (Please answer this question with respect to the majority of your land that is in rotation.)
   - ☐ During the crawfish season, I rent the land from the individual who produces the rotation crop.
   - ☐ During the rotation crop season, the individual who produces the rotation crop rents the land from me.
   - ☐ Both the individual who produces the rotation crop and I rent the land from a third party.
   - ☐ The individual who produces the rotation crop and I maintain joint ownership of the land.
   - ☐ Other **(Please specify)**______________________

7. Do you lease your farm for hunting leases? ☐ Yes ☐ No If yes, what species is being hunted?______________

8. What is your annual average yield of crawfish harvested per acre from each of the following systems? **(Please fill in ONLY those that apply to your farm.)**

lbs/acre/yr	***System***	***lbs/acre/yr***	***System***
________	Rice-Crawfish Double-Crop	________	Single-crop Crawfish with Rice Forage
________	Rice-Crawfish-Fallow Rotation	________	Single-crop Crawfish with Other Planted Forage
________	Rice-Crawfish-Soybeans Rotation	________	Single-crop Crawfish with Non-planted Forage Crop

9. For the months you harvest crawfish, on a given harvest day, how many lbs/acre *do you expect* to harvest on your farm?

Month	***lbs/acre/harvest day***	***Month***	***lbs/acre/harvest day***	***Month***	***lbs/acre/harvest day***
October	________	February	________	June	________
November	________	March	________	July	________
December	________	April	________	August	________
January	________	May	________		

10. During what month do you ***first*** flood your crawfish ponds?
   ☐August ☐ September ☐ October ☐ November ☐ December ☐ Other (Please list)__________

11. How many days does it take you to flood your crawfish ponds at first flood?__________Days
   How many inches of water are placed in the pond at first flood? ____________Inches

12. For a given field, how many hours per month do you usually pump during each of the following months, ***NOT including first flood***?

October	________	January	________	April	________	July	________
November	________	February	________	May	________	August	________
December	________	March	________	June	________		

13. How many times per season do you replace all or a portion of the water in your ponds, usually in an attempt to increase the dissolved oxygen content? ☐ Never ☐ Once ☐ Twice ☐ 3 times ☐ ≥4 times

14. What is your average annual water usage per acre for flooding of crawfish ponds? (If you fill your pond to an average depth of 18 inches and you subsequently require an additional 24 inches of water due to evaporation and seepage loss, then the total would be 18 +24 = 42 inches, so you would check 31-60 inches/acre.)
   ☐ 0-30 inches/acre ☐ 31-60 inches/acre ☐ 61-90 inches/acre ☐ 91-120 inches/acre ☐ >120 inches/acre

15. What is your water source for flooding ponds? Please fill in the additional specs if known.
   - ☐ Subsurface well(s) no. of wells_______ avg depth ______ft avg diameter______ft
   - ☐ Surface pump(s) (river, canal, marsh) no. of pumps______ avg depth ______ft avg diameter______ft

16. What types and sizes of pumps are used in flooding? Please fill in the additional specs if known.
   - ☐ Electric Pump(s) number ________ size (gallons/hour) ________ horsepower _______
   - ☐ Diesel Pump(s) number ________ size (gallons/hour) ________ horsepower _______

17. What is your main method used for harvesting crawfish? **(Please check ✓ all that apply.)**
   ☐ Boat ☐ Walking ☐ Other **(Please list)**_________

18. If a boat is used for harvesting crawfish, what type is used? **(Please check ✓ all that apply.)**
   ☐ Go-devil (mud motor) ☐ Hydraulic boat ☐ Push boat ☐ Other **(Please describe)**____________

19. Please check the months that you typically harvest crawfish in your operation:
   ☐ October ☐ December ☐ February ☐ April ☐ June ☐ August
   ☐ November ☐ January ☐ March ☐ May ☐ July ☐ September

20. Please check the box that indicates how often you harvest crawfish during each of the following seasons.

Early Season (October-January)	☐ Daily	☐ Every other day	☐ Every 3rd day	☐ Once a week	☐ Other____
Mid-Season (February-May)	☐ Daily	☐ Every other day	☐ Every 3rd day	☐ Once a week	☐ Other____
Late Season (June-August)	☐ Daily	☐ Every other day	☐ Every 3rd day	☐ Once a week	☐ Other____

21. How many traps are generally used per acre?
☐ 1-5 ☐ 6-10 ☐ 11-15 ☐ 16-20 ☐ 21-25 ☐ 26-30 ☐ ≥31

22. What type of mesh wire is used in the construction of your traps?
☐ 3/4 inch hex ☐ 3/4 inch square ☐ 7/8 inch hex ☐ 7/8 inch square ☐ Other (**Please list**)________

23. How many paid employees work **full-time** (≥30 hrs/week) in your crawfish enterprise during each of the following seasons? (**Please check ✓ one box for each season.**)

Early Season (October-January)	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ ≥5
Mid-Season (February-May)	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ ≥5
Late Season (June-August)	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ ≥5

24. How many paid employees work **part-time** (<30 hrs/week) in your crawfish enterprise during each of the following seasons? (**Please check ✓ one box for each season.**)

Early Season (October-January)	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ ≥5
Mid-Season (February-May)	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ ≥5
Late Season (June-August)	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ ≥5

25. How many **family members** (besides yourself) work in your crawfish enterprise during each of the following seasons?

Early Season (October-January)	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ ≥5
Mid-Season (February-May)	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ ≥5
Late Season (June-August)	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ ≥5

26. About how many total hours per year are spent repairing levees on your farm? (If *you* spend 30 hours and a *hired person* spends 20 hours, then the total would be 30+20=50 hours, so you would check 41-60 hrs.)
☐ 0-20 hrs ☐ 21-40 hrs ☐ 41-60 hrs ☐ 61-80 hrs ☐ 81-100 hrs ☐ ≥101 hrs

27. If you use temporary levees, what is their average height and width?__________feet high __________feet wide

28. How do you check **dissolved oxygen** levels in your crawfish ponds?
☐ Dissolved oxygen meter ☐ Oxygen test kit ☐ Other________ ☐ I do not test oxygen levels.

29. Do you use **hay** for supplemental feeding of crawfish? ☐ Yes ☐ No
If you answered "Yes," then approximately how much hay per acre per year is used? _________lbs/acre/year

30. Do you use **pelleted feeds** for supplemental feeding of crawfish? ☐ Yes ☐ No
If you answered "Yes," then approximately how much is used per acre per year? ___________lbs/acre/year

31. Please check ✓ all of the **baits** you use and (if known) indicate the total amounts purchased per year of each.

Bait Type	***Amount Used Annually (Indicate Units <u>or</u> Dollars)***	***Bait Type***	***Amount Used Annually (Indicate Units <u>or</u> Dollars)***
☐ Menhaden (pogy)	__________	☐ Mullet	__________
☐ Herring (slicker)	__________	☐ Heads & viscera of processed fish	__________
☐ Carp	__________	☐ Manufactured bait	__________
☐ Suckers	__________	☐ Other__________	__________
☐ Shad	__________		

32. Which of the following **marketing outlets** do you use to sell crawfish? (**Please check ✓all that apply**.)
☐ I sell to a processor. ☐ I sell to a wholesaler. ☐ I sell to a retailer. ☐ I sell directly to consumers.

33. Do you, at least sometimes:

grade your crawfish prior to selling them?	☐ Yes	☐ No
wash your crawfish prior to selling them?	☐ Yes	☐ No
purge your crawfish prior to selling them?	☐ Yes	☐ No
own or run a commercial crawfish peeling operation?	☐ Yes	☐ No

34. Do you ***use sediments from the pond bottom itself*** as the first soil source for rebuilding levees and filling low areas?
☐ Yes ☐ No

35. Do you, at least sometimes:

capture and store rainfall to reduce pumping costs?	☐ Yes	☐ No
minimize sediment loading by any method when draining?	☐ Yes	☐ No
reuse pond water for crawfish production?	☐ Yes	☐ No
use ***tail-water for irrigation*** on crops other than crawfish?	☐ Yes	☐ No
use a ***soil test*** to determine the nutrients needed to produce a forage crop for crawfish?	☐ Yes	☐ No
avoid pumping and draining at the same time?	☐ Yes	☐ No

36. Have you installed outlets to drain water overflow from the *pond surface*? ☐ Yes ☐ No

37. ***Water detention during summer drawdown*** refers to allowing crawfish ponds to sit for several days or weeks prior to final draining to reduce loss of nutrients and soil. Do you use this practice? ☐ Yes ☐ No

38. Do you believe your crawfish production was reduced during 2007/08 due to **White Spot Disease**?
☐ Yes (**Please proceed to question 39**) ☐ No (**Please proceed to question 40**)

39. If "Yes" to question 38, what percentage of your total production do you believe was lost during 2007/08 due to White Spot Disease? ☐ ≤10% ☐ 11%-20% ☐ 21%-30% ☐ 31%-40% ☐ ≥41%

40. For which **Nuisance Wildlife** species do you incur control costs?
☐ Mink ☐ Otter ☐ Raccoon ☐ Muskrat ☐ Nutria ☐ Birds ☐ Other___________
How much do you spend annually for controlling **Nuisance Wildlife** for your crawfish enterprise?___________$/year.

Please answer the following questions regarding 18 Best Management Practices (BMPs) for crawfish production. For each question, please mark only the <u>ONE ANSWER THAT BEST REFLECTS</u> your reasons for adopting or not adopting.

1. ***<u>Conservation Cover</u>*** is the practice of establishing and maintaining permanent vegetative cover. This helps in improving air, water, and soil quality as well as in reducing soil erosion. Is this practice used on your farm?
   - ☐ Yes, I established it because it leads to increased profit.
   - ☐ Yes, I established it because it is good for the environment.
   - ☐ Yes, I established it because I have been encouraged/required to do so.
   - ☐ Yes, I established it since it's good for long-run land productivity.
   - ☐ Yes, this practice was established by the landowner or another tenant.
   - ☐ No, I am not familiar with this practice.
   - ☐ No, this doesn't apply to my farm.
   - ☐ No, this would reduce my profit.
   - ☐ No, I am still considering doing this.
   - ☐ No, I prefer not to do this.

2. ***<u>Critical Area Planting</u>*** is the establishment of permanent vegetation on sites that have high erosion rates, and on sites that have conditions that prevent establishment of vegetation with normal practices. Is this practice used on your farm?
   - ☐ Yes, I established it because it leads to increased profit.
   - ☐ Yes, I established it because it is good for the environment.
   - ☐ Yes, I established it because I have been encouraged/required to do so.
   - ☐ Yes, I established it since it's good for long-run land productivity.
   - ☐ Yes, this practice was established by the landowner or another tenant.
   - ☐ No, I am not familiar with this practice.
   - ☐ No, this doesn't apply to my farm.
   - ☐ No, this would reduce my profit.
   - ☐ No, I am still considering doing this.
   - ☐ No, I prefer not to do this.

3. A ***<u>Field Border</u>*** is a strip of permanent vegetation established at the edge or perimeter of a field. It helps reduce soil erosion, improve soil and water quality, and increase carbon storage. Are field borders used on your farm?
   - ☐ Yes, I established it because it leads to increased profit.
   - ☐ Yes, I established it because it is good for the environment.
   - ☐ Yes, I established it because I have been encouraged/required to do so.
   - ☐ Yes, I established it since it's good for long-run land productivity.
   - ☐ Yes, this practice was established by the landowner or another tenant.
   - ☐ No, I am not familiar with this practice.
   - ☐ No, this doesn't apply to my farm.
   - ☐ No, this would reduce my profit.
   - ☐ No, I am still considering doing this.
   - ☐ No, I prefer not to do this.

4. A ***<u>Grade Stabilization Structure</u>*** is a structure used to control the slope in natural or artificial channels. Is a grade stabilization structure used on your farm?
   - ☐ Yes, I adopted it because it leads to increased profit.
   - ☐ Yes, I adopted it because it is good for the environment.
   - ☐ Yes, I adopted it because I have been encouraged/required to do so.
   - ☐ Yes, I adopted it since it's good for long-run land productivity.
   - ☐ Yes, this structure was adopted by the landowner or another tenant.
   - ☐ No, I am not familiar with this practice.
   - ☐ No, this doesn't apply to my farm.
   - ☐ No, this would reduce my profit.
   - ☐ No, I am still considering doing this.
   - ☐ No, I prefer not to do this.

5. ***Filter Strips*** are strips of grasses or other close-growing vegetation planted around fields and along drainage ways and water bodies. The purpose is to reduce sediment, organic material, nutrients, and chemicals carried in runoff, in the case of crawfish production in inflow and discharging water. Are filter strips used on your farm?

☐ Yes, I established it because it leads to increased profit.	☐ No, I am not familiar with this practice.
☐ Yes, I established it because it is good for the environment.	☐ No, this doesn't apply to my farm.
☐ Yes, I established it because I have been encouraged/required to do so.	☐ No, this would reduce my profit.
☐ Yes, I established it since it's good for long-run land productivity.	☐ No, I am still considering doing this.
☐ Yes, this practice was established by the landowner or another tenant.	☐ No, I prefer not to do this.

6. A ***Grassed Waterway*** is a natural or constructed channel that is shaped or graded to required dimensions and established with suitable vegetation. Are grassed waterways used on your farm?

☐ Yes, I established it because it leads to increased profit.	☐ No, I am not familiar with this practice.
☐ Yes, I established it because it is good for the environment.	☐ No, this doesn't apply to my farm.
☐ Yes, I established it because I have been encouraged/required to do so.	☐ No, this would reduce my profit.
☐ Yes, I established it since it's good for long-run land productivity.	☐ No, I am still considering doing this.
☐ Yes, this practice was established by the landowner or another tenant.	☐ No, I prefer not to do this.

7. ***Irrigation Water Management*** is the process of controlling irrigation water volume, frequency, and application rate for forage and crawfish in a planned, efficient manner. Is irrigation water management practiced on your farm?

☐ Yes, I practice it because it leads to increased profit.	☐ No, I am not familiar with this practice.
☐ Yes, I practice it because it is good for the environment.	☐ No, this doesn't apply to my farm.
☐ Yes, I practice it because I have been encouraged/required to do so.	☐ No, this would reduce my profit.
☐ Yes, I practice it since it's good for long-run land productivity.	☐ No, I am still considering doing this.
☐ Yes, this practice was established by the landowner or another tenant.	☐ No, I prefer not to do this.

8. ***Irrigation Land Leveling*** is reshaping the surface of land to be irrigated to planned grades. Has irrigation land leveling been done on your farm?

☐ Yes, I adopted it because it leads to increased profit.	☐ No, I am not familiar with this practice.
☐ Yes, I adopted it because it is good for the environment.	☐ No, this doesn't apply to my farm.
☐ Yes, I adopted it because I have been encouraged/required to do so.	☐ No, this would reduce my profit.
☐ Yes, I adopted it since it's good for long-run land productivity.	☐ No, I am still considering doing this.
☐ Yes, this practice was adopted by the landowner or another tenant.	☐ No, I prefer not to do this.

9. An ***Irrigation Storage Reservoir*** is an irrigation water storage structure made by constructing a dam, embankment, or pit. It holds water in storage until it is used for irrigation. Is an irrigation storage reservoir used on your farm?

☐ Yes, I adopted it because it leads to increased profit.	☐ No, I am not familiar with this practice.
☐ Yes, I adopted it because it is good for the environment.	☐ No, this doesn't apply to my farm.
☐ Yes, I adopted it because I have been encouraged/required to do so.	☐ No, this would reduce my profit.
☐ Yes, I adopted it since it's good for long-run land productivity.	☐ No, I am still considering doing this.
☐ Yes, this practice was adopted by the landowner or another tenant.	☐ No, I prefer not to do this.

10. An ***Irrigation Regulating Reservoir*** is a small storage reservoir constructed to regulate an irrigation water supply. It is designed primarily for flow control or to store water for a few hours or days, but does not generally include detailed design criteria. Is an irrigation regulating reservoir used on your farm?

☐ Yes, I adopted it because it leads to increased profit.	☐ No, I am not familiar with this practice.
☐ Yes, I adopted it because it is good for the environment.	☐ No, this doesn't apply to my farm.
☐ Yes, I adopted it because I have been encouraged/required to do so.	☐ No, this would reduce my profit.
☐ Yes, I adopted it since it's good for long-run land productivity.	☐ No, I am still considering doing this.
☐ Yes, this practice was adopted by the landowner or another tenant.	☐ No, I prefer not to do this.

11. An ***Irrigation System with Tailwater Recovery*** is a planned irrigation system with facilities installed for collection, storage, and transportation of irrigation tailwater and/or rainfall runoff for reuse. Is this practice used on your farm?

☐ Yes, I established it because it leads to increased profit.	☐ No, I am not familiar with this practice.
☐ Yes, I established it because it is good for the environment.	☐ No, this doesn't apply to my farm.
☐ Yes, I established it because I have been encouraged/required to do so.	☐ No, this would reduce my profit.
☐ Yes, I established it since it's good for long-run land productivity.	☐ No, I am still considering doing this.
☐ Yes, this practice was established by the landowner or another tenant.	☐ No, I prefer not to do this.

12. An ***Irrigation Water Conveyance via a Pipeline*** is a pipeline installed in an irrigation system to prevent erosion, loss of water quality, or damage to land. Has a pipeline for irrigation water conveyance been installed on your farm?

☐ Yes, I adopted it because it leads to increased profit.	☐ No, I am not familiar with this practice.
☐ Yes, I adopted it because it is good for the environment.	☐ No, this doesn't apply to my farm.
☐ Yes, I adopted it because I have been encouraged/required to do so.	☐ No, this would reduce my profit.
☐ Yes, I adopted it since it's good for long-run land productivity.	☐ No, I am still considering doing this.
☐ Yes, this practice was adopted by the landowner or another tenant.	☐ No, I prefer not to do this.

13. ***Nutrient Management*** is managing the amount, source, placement, form and timing of the application of plant nutrients and soil amendments. Is nutrient management practiced on your farm?

- ☐ Yes, I practice it because it leads to increased profit.
- ☐ Yes, I practice it because it is good for the environment.
- ☐ Yes, I practice it because I have been encouraged/required to do so.
- ☐ Yes, I practice it since it's good for long-run land productivity.
- ☐ Yes, this practice is used by the landowner or another tenant.
- ☐ No, I am not familiar with this practice.
- ☐ No, this doesn't apply to my farm.
- ☐ No, this would reduce my profit.
- ☐ No, I am still considering doing this.
- ☐ No, I prefer not to do this.

14. A ***Pumping Plant*** is used to transfer water for a conservation need. Has a pumping plant been installed on your farm?

- ☐ Yes, I adopted it because it leads to increased profit.
- ☐ Yes, I adopted it because it is good for the environment.
- ☐ Yes, I adopted it because I have been encouraged/required to do so.
- ☐ Yes, I adopted it since it's good for long-run land productivity.
- ☐ Yes, this practice was adopted by the landowner or another tenant.
- ☐ No, I am not familiar with this practice.
- ☐ No, this doesn't apply to my farm.
- ☐ No, this would reduce my profit.
- ☐ No, I am still considering doing this.
- ☐ No, I prefer not to do this.

15. ***Range Planting*** is the establishment of perennial vegetation such as grasses, forbs, legumes, shrubs and trees. Has a range planting been established on your farm?

- ☐ Yes, I established it because it leads to increased profit.
- ☐ Yes, I established it because it is good for the environment.
- ☐ Yes, I established it because I have been encouraged/required to do so.
- ☐ Yes, I established it since it's good for long-run land productivity.
- ☐ Yes, this practice was established by the landowner or another tenant.
- ☐ No, I am not familiar with this practice.
- ☐ No, this doesn't apply to my farm.
- ☐ No, this would reduce my profit.
- ☐ No, I am still considering doing this.
- ☐ No, I prefer not to do this.

16. A ***Riparian Forest Buffer*** is an area of predominantly trees and/or shrubs located adjacent to and uphill from a water body. Has a riparian forest buffer been established on your farm?

- ☐ Yes, I established it because it leads to increased profit.
- ☐ Yes, I established it because it is good for the environment.
- ☐ Yes, I established it because I have been encouraged/required to do so.
- ☐ Yes, I established it since it's good for long-run land productivity.
- ☐ Yes, this practice was established by the landowner or another tenant.
- ☐ No, I am not familiar with this practice.
- ☐ No, this doesn't apply to my farm.
- ☐ No, this would reduce my profit.
- ☐ No, I am still considering doing this.
- ☐ No, I prefer not to do this.

17. ***Streambank & Shoreline Protection*** is a treatment used to stabilize and protect banks of waterbodies: lakes, streams, constructed channels, reservoirs, or estuaries. Has streambank and shoreline protection been established on your farm?

- ☐ Yes, I established it because it leads to increased profit.
- ☐ Yes, I established it because it is good for the environment.
- ☐ Yes, I established it because I have been encouraged/required to do so.
- ☐ Yes, I established it since it's good for long-run land productivity.
- ☐ Yes, this practice was established by the landowner or another tenant.
- ☐ No, I am not familiar with this practice.
- ☐ No, this doesn't apply to my farm.
- ☐ No, this would reduce my profit.
- ☐ No, I am still considering doing this.
- ☐ No, I prefer not to do this.

18. ***Tree/Shrub Establishment*** is the establishment of woody plants by planting seedlings or cuttings, direct seeding, or natural regeneration. Has a tree/shrub establishment been adopted on your farm?

- ☐ Yes, I established it because it leads to increased profit.
- ☐ Yes, I established it because it is good for the environment.
- ☐ Yes, I established it because I have been encouraged/required to do so.
- ☐ Yes, I established it since it's good for long-run land productivity.
- ☐ Yes, this practice was established by the landowner or another tenant.
- ☐ No, I am not familiar with this practice.
- ☐ No, this doesn't apply to my farm.
- ☐ No, this would reduce my profit.
- ☐ No, I am still considering doing this.
- ☐ No, I prefer not to do this.

19. Have you participated in any government cost-sharing programs such as the Environmental Quality Incentives Program (EQIP) while implementing a BMP?

- ☐ Yes **(Please proceed to question 20)**
- ☐ No **(Please proceed to question 21)**

20. If you answered "Yes" to question 19, for which of the following BMPs are you receiving a cost share? **(Please check ✓ all that apply.)**

- ☐ Conservation Cover
- ☐ Critical Area Planting
- ☐ Field Border
- ☐ Grade Stabilization Structure
- ☐ Filter Strip
- ☐ Grassed Waterway
- ☐ Irrigation Water Management
- ☐ Irrigation Land Leveling
- ☐ Irrigation Storage Reservoir
- ☐ Irrigation Regulating Reservoir
- ☐ Irr. System, Tailwater Recovery
- ☐ Irr. Water Conveyance-Pipeline
- ☐ Nutrient Management
- ☐ Pumping Plant
- ☐ Range Planting
- ☐ Riparian Forest Buffer
- ☐ Streambank & Shoreline Protection
- ☐ Tree/Shrub Establishment

21. Consider the ***combination of BMPs*** listed above in 1-18 that you have adopted. How do you think the combination ***you have adopted*** has impacted your profit as compared to if you hadn't adopted them? My combination of BMPs has:
   - ☐ Lowered my crawfish profit by ≥21%.
   - ☐ Lowered my crawfish profit by 11% to 20%.
   - ☐ Lowered my crawfish profit by 1% to 10%.
   - ☐ Not impacted my crawfish profit.
   - ☐ Increased my crawfish profit by 1% to 10%.
   - ☐ Increased my crawfish profit by 11% to 20%.
   - ☐ Increased my crawfish profit by ≥21%.

Please answer the following questions regarding record-keeping systems for your crawfish operation.

1. Who keeps your farm records? ☐ My spouse and/or I ☐ Farm business personnel ☐ External professional
2. Do you use a **computer** for record-keeping purposes in your farm operation? ☐ Yes ☐ No
3. Do you use the **internet** to assist you with farm decision-making? ☐ Yes ☐ No
4. Please check **each** of the following types of **financial statements** you prepare and use in your management activities:
   ☐ Income Statement ☐ Cash Flow Statement ☐ Balance Sheet ☐ Statement of Owner's Equity

Please answer the following questions about yourself.

1. How many years have you been farming crawfish?
   ☐ 1-7 years ☐ 8-14 years ☐ 15-21 years ☐ 22-28 years ☐ 29-35 years ☐ 36-42 years ☐ ≥43 years.
2. Please indicate your highest level of education.
   ☐ Less than high school ☐ High school diploma / GED ☐ Some college / technical school ☐ Bachelor's Degree ☐ Advanced degree (M.S., Ph.D., J.D., M.D., etc.)
3. Approximately what percentage of your total **household income** came from the **farming operation** in 2007?
   ☐ 1-19% ☐ 20-39% ☐ 40-59% ☐ 60-79% ☐ 80-100%
4. Approximately what percentage of your **farming income** came from **crawfish** in 2007?
   ☐ 1-19% ☐ 20-39% ☐ 40-59% ☐ 60-79% ☐ 80-100%
5. Do you hold an **off-farm job**? ☐ Yes ☐ No
6. Please indicate your **age.** ☐ ≤30 ☐ 31-45 ☐ 46-60 ☐ 61-75 ☐ ≥76
7. Over the past year, approximately how many **business contacts** (visits, attended seminars, etc.) have you had with:
   Natural Resource Conservation Service (NRCS) personnel? ☐ None ☐ 1 ☐ 2 ☐ 3 ☐ ≥4
   Louisiana Cooperative Extension Service personnel? ☐ None ☐ 1 ☐ 2 ☐ 3 ☐ ≥4
8. Relative to other investors, how would you characterize yourself? **(Please check one)**
   - ☐ I tend to take on substantial levels of risk in my investment decisions.
   - ☐ I tend to avoid risk when possible in my investment decisions.
   - ☐ I neither seek nor avoid risk in my investment decisions.
9. Compared to other farmers in your area, which of the following best describes your willingness to adopt new technologies? **(Please check one)**
   - ☐ I tend to adopt new technology earlier than most of my neighbors.
   - ☐ I tend to adopt new technology along with most of my neighbors.
   - ☐ I tend to wait until others have adopted new technology to see how well the technology works before adopting.
10. How far from your crawfish farm is the **nearest stream or river**?
    ☐ A stream/river runs through my farm. ☐ ≤1 mile ☐ >1 mile
11. Is any of the land on your farming operation considered highly erodible? ☐ Yes ☐ No ☐ I don't know

In order to update our annual crawfish production budgets, we will need to contact some producers via a 5-10 minute telephone call to ask about machinery use. Would you be willing to have us call you in the next 2 months for this purpose?
☐ Yes ☐ No

Thank you for your time and participation!

APPENDIX B
"MULTICOLLINEARITY DIAGNOSTIC RESULTS"

Table 5.1: Test of Multi-collinearity Results

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Variance Inflation
Intercept	Intercept	1	-0.11541	0.36892	-0.31	0.7556	0
ACRES	ACRES	1	0.00000654	0.00009329	0.07	0.9444	1.84504
cash		1	0.00544	0.14368	0.04	0.9699	1.33542
share		1	0.21714	0.18556	1.17	0.2471	1.24216
doublecrop		1	0.03970	0.16140	0.25	0.8066	1.35072
rotation		1	-0.27761	0.16287	-1.70	0.0940	1.54074
YEARSFARM	YEARSFARM	1	0.04982	0.04236	1.18	0.2447	1.18708
FARMINCOME	FARMINCOME	1	-0.05213	0.04282	-1.22	0.2287	1.19532
HHINCOME	HHINCOME	1	0.02854	0.04507	0.63	0.5293	1.53119
AGE	AGE	1	0.17454	0.09669	1.81	0.0766	1.25302
college		1	-0.02672	0.13335	-0.20	0.8420	1.23296
nohs		1	0.10377	0.25739	0.40	0.6884	1.29617
riskaverse		1	-0.09732	0.13949	-0.70	0.4884	1.41565
techadoptearly		1	0.34960	0.14156	2.47	0.0167	1.29622
stream1		1	-0.17688	0.13067	-1.35	0.1815	1.22150

Collinearity Diagnostics

Number	Eigenvalue	Condition Index	Proportion of Variation Intercept	ACRES	cash	share
1	7.95122	1.00000	0.00037916	0.00276	0.00252	0.00208
2	1.36002	2.41793	0.00011842	0.02788	0.05975	0.02013
3	1.01809	2.79462	0.00006696	0.00225	0.04963	0.32300
4	0.85473	3.05001	0.00008833	0.03434	0.03894	0.06515
5	0.80388	3.14500	0.00000749	0.00172	0.04334	0.03403
6	0.66273	3.46376	0.00006947	0.00086873	0.00913	0.00789
7	0.54920	3.80497	4.874368E-7	0.00897	0.26896	0.32329
8	0.50134	3.98247	2.14625E-7	0.00446	0.00012345	0.00036266
9	0.38110	4.56771	0.00058310	0.30543	0.18345	0.05073
10	0.29676	5.17626	0.00025442	0.00266	0.01041	0.01686
11	0.24163	5.73641	0.00115	0.20031	0.01542	0.07572
12	0.16776	6.88460	0.00268	0.19384	0.28695	0.02787
13	0.12186	8.07757	0.00057162	0.18409	0.00030086	0.00863
14	0.07246	10.47528	0.06620	0.02842	0.00082567	0.00896
15	0.01722	21.48894	0.92783	0.00199	0.03027	0.03530

VITA

The native of one of the most beautiful Himalayan countries, Nepal, Narayan had an in-depth interest in agriculture from his childhood. After completing his School Level Certificate (SLC) from Shree Wakwani Higher Secondary School, Ramnagar, Nawalparasi, in 1997, he joined Institute of Agriculture and Animal Science (IAAS), Paklihawa, Rupandehi, for his Intermediate degree. In 1999, he started his bachelor's of science (Agriculture) in IAAS, Rampur, Chitwan, and completed in 2003.

He began his master's program in the Department of Agricultural Economics and Agribusiness, LSU, in the spring 2008. After completing his master's degree, he will be pursuing his doctoral degree.